THE

POPULAR SCIENCE MONTHLY.

SEPTEMBER, 1878.

THE PLACE OF CONSCIENCE IN EVOLUTION.

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OF all the objections and difficulties that sprang into life the moment that the doctrine of evolution was propounded for our acceptance, very few indeed (exclusive of the purely scientific ones) now give evidence of persistent vitality. Time, which, if age and experience can give wisdom, ought to be so much wiser than any of us, has consigned the greater part of them to oblivion, and evolution is taking its place, one might say, as part of the furniture of the human mind. Chief among these objections was the assertion that evolution could give no satisfactory account of the origin of morality and the genesis of conscience.

Many persons, religious thinkers especially, among whom Mr. Charles Kingsley may be cited as an instance, while willing to accept any reasonable conclusion of science as to the origin and constitution of man, appeared determined to reserve conscience as something inexplicable by any effort of human thinking, and therefore as a direct gift of God to his creatures; others, again, have gone so far as to assert that the idea of duty as of divine obligation must perish, if the nature and growth of conscience could be explained, as part of the evolution of the race, by natural causation. This feeling, natural and indeed honorable, was strengthened by the fact that the explanation given of the place of conscience in evolution seemed to unprejudiced minds—seemed also to that *communis sensus* which is, after all, the ultimate court of arbitration in these matters—on the whole inadequate to account for the phenomenon for which explanation was desired. These persistently averred that they were conscious of something within them which no considerations derived from utility or from social life, or from the transference of external sanctions to the inward individual con-

sciousness, at all explained or enforced. To a certain extent this feeling was itself a justification of resistance to the claims of evolution to be regarded as a sufficient history of the creation of man. The evolutionists had claimed to be able to make clear to its possessors the mystery of conscience; and if reasonable men asserted that, so far as they were concerned, the sense of mystery remained, it was clear that the last word on the subject was not yet spoken.

I am certainly very far from thinking that the last word will be spoken for some time to come, but I make bold to believe that it is possible to throw further light upon the subject without at all departing from the general principle of evolution to which I have for long given such intellectual adherence as was in my power. Let us, then, begin by endeavoring to understand what were the precise features in the power called conscience, which seemed to intuitional thinkers to baffle and defy the explanations of the evolutionists.

Their general point of view may be fairly expressed by the statement that the conscience must have had an existence prior to the conditions out of which it was supposed to have been evolved. Drawn out in detail, this statement contains the three following propositions:

1. Conscience is instantaneous—that is, innate—in its origin, and therefore not to be accounted for by the supposition that by degrees it was impressed upon the mind from without. It bears so strong a resemblance to the other faculties, the senses and emotions, that, like them, it must have formed part of the original constitution of man. When examined it seems to testify that it is in no sense a composition, not made up of long and varied experiences, but the result of a single creative act, or at any rate the instantaneous product of certain conditions brought for the first time into relation with each other. In other words, the length of time postulated by evolutionists for the development of man is not granted them in the case of conscience. We shall see presently whether they really require it.

2. Conscience is instantaneous—that is, intuitional—in its operations, and therefore not to be accounted for by the action and reaction of social relationships. Had there been but one man, that one man would have been able to say, "I must do this;" and, again, there must have been a sense that it was right to combine for social purposes of mutual help and comfort before men could have conceived the idea of doing so. The notion that I ought to act in a certain way toward my neighbor is, if not a primary, at least a very easy one, whereas the notion that I ought to act in a certain way, because it is for his or our advantage, seems *prima facie* a much later one. There is, in short, a correlation between the conscience and an external rightness, which is just as natural, as rapid, as unaffected by later relationships, as is the correlation between the eye and light. In primeval man the conscience detects, however dimly and imperfectly, morality in actions just as the eye detects shape and color in objects. Social and civilized life may

enable him to see more clearly and explain more completely, but it cannot give him either the eye or the conscience.

3. Conscience is also instantaneous—that is, imperative—in its commands. It never stops to argue when once the right is, or is thought to be, ascertained. But if mankind had reached the lofty heights of duty by the ladder of utility or the gradually-growing influence of external sanctions, it might have been expected that some fragments of the ladder, some traces of the process, some memory of the time when "ought" was a word of dubious meaning and uncertain cogency, would have been preserved. The evidence derivable from the histories of savage existence seems plainly to indicate that this imperativeness of conscience is inseparable from the most rudimentary stage of moral and social life. In short, to put the matter as briefly as possible, those who object to the theory of evolution maintain that it is impossible to conceive of any creature entitled to the name of a human being who was not as much furnished with a conscience as any of his successors. True, the primeval conscience had not begun to construct moral rules any more than the primeval eye had formed theories of light and form; but the existence of both was equally indisputable and essential to the idea of man.

Now, if it can be shown that there is a place in evolution for the formation of a conscience fulfilling all these conditions—if, that is, the theory of evolution can be proved to account precisely for those phenomena that seem *prima facie* to militate most strongly against it—if this feature, which I have called instantaneousness, and have exhibited in three of its leading characteristics, is exactly what one might expect to find in the evolution of the human race—then I submit we have obtained a confirmation of the truth of the said theory of that nature which appeals most forcibly to the common-sense and practical judgment of mankind. Let this, then, be the judge as to whether all that is instantaneous in conscience is not fully accounted for by the considerations I am about to urge.

In seeking to account for the origin of man by evolution we are frequently obliged to confess that the entire absence of contemporary evidence compels us, at any rate for the present, to say of many phenomena, that if we knew more we should be able to answer difficulties and clear up perplexities which seem at this present moment wellnigh insuperable. The gaps are such that they cannot be filled up even by the imagination. Science has done but little yet to enable the intellect to form an idea to itself of the way in which organic life and reasoning man began to exist upon the earth. Impenetrable darkness hangs over vast epochs, nor is it possible in the present absence of materials to fill in the picture of that critical time when man (slowly or suddenly, who can tell?) rose up from among the beasts and said, or rather felt without being able to say, "I am." But then by our hypothesis this is also the time when he also said, "I must." We may feel assured that at this time,

by orderly development and natural process of causation, all that is most vital and precious to humanity, all the seeds of man's present and eternal future, came into existence; but none the less is the darkness so great that even the imagination refuses to move from its place. The surrounding objects are there if the light would but dawn so as to enable us to see them. It is very necessary to remind ourselves of this, lest we seem to be expressing ourselves with too much certainty in doubtful matters. But however necessary this may be when we are dealing with many other questions respecting the origin of man, it is, I firmly believe, by no means so necessary in our present investigation. That phenomenon, called conscience, which seemed at first sight the most likely to resist analysis by way of evolution, proves upon experiment to yield most readily to it.

As usual in questions of this description, philosophy has been made the slave, the victim, and finally the accomplice of language. The word conscience has come to suggest a kind of special faculty, not exactly thought and not exactly feeling, which presides over a specific department of man's being, namely, his moral conduct. Whereas, reduced to its simplest elements, conscience is merely the power which the mind possesses of discerning rightness. Just as we discern something called beautiful which we must admire, or something called pleasurable which we must seek, so do we perceive something right which we must do. And so our specific question comes to this, "How did the idea or the fact of rightness enter into the world?"

There can, I think, be no doubt that the general tendency of the teaching of evolution has been to reintroduce into philosophy the idea that such things as virtue, goodness, happiness, right, are absolute and fixed quantities, formed for man and not by him, existing independently of him, and therefore the same to all men in all circumstances. They are realized by the complete and harmonious adjustment of the self-conscious ego to the circumstances out of which it came and by which it is surrounded. Can, then, evolution help us to perceive how the idea of there being such a thing as absolute fixed rightness came into the world?

Let us transfer ourselves in thought as far back as the time when the origin of man took place, and let us imagine a being slowly or suddenly arriving at the stage of self-conscious existence. For our present purpose it matters little whether we attribute this to a gradual progress, or (what is surely possible) to a sudden but natural leap in evolution, or to a special act of creation adapting itself to materials already at its disposal. (I mention this last alternative merely to show that this theory of the origin of conscience does not conflict with any reasonable hypothesis as to the origin of man.) Now this Being owed his origin to the law or process of natural selection. He had been cradled, so to speak, under conditions which prescribed a continual struggle for existence, and which permitted only the strongest and fittest to survive and multiply. His "conduct" up to the moment or epoch when it be-

came self-conscious was confined to these two spheres of action, flying (by combination and otherwise) for life and killing for life. There were creatures whom it was natural for him to kill, and others who, it was equally natural, should kill him. This was the state of things in which he found himself a living, thinking being; this was the law which he found not only confronting him on every side of his exterior life, but also deep rooted in his inmost nature as an indubitable, unanswerable fact.

Having arrived at this point, let us as our next step remind ourselves that it is impossible to imagine a rational human being in whom there is not present the assurance that he has a right to himself, to be allowed to live in the first place, afterward (as the result maybe of long years of evolution) to be allowed to live happily. That no one has a right to take my life from me is a thought inseparable from myself, it is at any rate the first piece of knowledge of which I become possessed. The infant's cry for nourishment and warmth contains this much meaning to those who can discern how moral feelings grew out of physical conditions. But then this thought remains a mere mystery, and therefore quite unsuitable for affording a basis on which to explain the origin of conscience, until we set it in the light of evolution. So regarded, the mystery vanishes in an instant. For this thought is merely the necessary result of the correlation of the first self-conscious being with his environment, and conscience is the *struggle for existence become aware of itself in the mind of a thinking person.* The first man, in however dumb, inarticulate a fashion, did nevertheless practically contrive to claim of the universe, of Nature, of creatures like himself, nay, ultimately of the unknown Author of all things, that they should not destroy the life which they had originated. He made his appeal (makes it in truth now) to all the tremendous forces amid which he moved, and in the balance and play of which he endeavored to maintain an independent personal existence, that they should minister to *him*, the one thinking creature among them, and therefore (for the first man was also the first philosopher) their centre and final cause. It seemed to him, in short, right, could not indeed seem otherwise, the past being what it had been, that his environment should be such as would make life possible to him at once, and in due time useful and enjoyable.

Observe that the condition essential to all knowledge, namely, contrast or the perception of dissimilarities, is here present. As light is meaningless without darkness, or heat without cold, so is right without its contrast of force or wrong. No doubt primeval man may have for long perceived by sensation the contrast of heat and cold, day and night, before he so far separated the ideas as to give them abstract names. So, too, the same man may have for long felt the indescribable contrast between the external force that was everywhere threatening his existence and the internal force that was resolutely bent on con-

tinuing to be, before he called the two by the names right and wrong. But as the mere fact that the contrast was there, and always had been there, at the very root of things, produced at once the appropriate feeling in the first mind, so did the feeling produce in due time the words in which it is expressed. Take the first and commonest action in the struggle for existence. The meanest creature that lives seeks instinctively to escape from its enemy by flight. But man alone can think, as he flies from his pursuer, with an energy quickened by his knowledge of what death is and means: "All this is unutterably wrong. I have a right to save my life, this thing or creature has no right to take it from me." Such, or something like this, were the first thoughts of the first conscience, the first expression of the conviction that there was a rightness in the world.

Whatever else may be urged against this account of the origin of conscience, it seems to me certain that those phenomena, upon which intuitionalists have particularly relied as being beyond the reach of analysis, and therefore of discovery, are fully and precisely accounted for. Take, for instance, the word creation, which men have used because of their feeling that there were things in the world of instantaneous, and therefore of specially divine, origin—a feeling which gave rise to the most sublime utterance of antiquity: "God said, Let there be light, and there was light." Now the poetical beauty and religious truth of such phrases are surely not in the least degree prejudiced by the scientific statement that these "creations" correspond to those critical epochs in the progress of evolution when, by the union or marriage of one set of conditions with another, a third is instantaneously, and for the first time, called into being. Such an epoch, resulting in the origin of conscience, was that in which a being conscious of himself said, or thought, or felt, "I am," and then, confronted with a world of opposing and destructive forces, added, "and I have a right to be."

So, too, the truth contained in the assertion that conscience is innate, intuitional, and imperative, is seen to be in harmony with the foregoing account of its origin. It is innate in the sense that, though undoubtedly impressed from without during long periods upon man in his *animal state*, it was *not* gradually impressed upon him in his intelligent state, but was, from the first, part of the mental furniture with which as a rational being he commenced his life upon earth. It is, in short, not a composition, i. e., the result of various tendencies such as pleasure, utility, and the like, but, in the sense explained above, a creation, coeval with man himself, the inheritance of the first human being no less than of the last.

Again, it is intuitional in the sense that it has a direct necessary and immediate perception of an external something, named rightness, with which it is correlated. Man, by virtue of his conscience, is obliged to believe that there is right and wrong, just as by virtue of his eye he is obliged to believe there is light and darkness. And this belief exists

and must exist independently of all theories as to what in the abstract constitutes right and wrong, and in spite of mistakes in particular cases.

Lastly, conscience is imperative, because the inwrought consciousness in human nature that man has a right to himself makes every other consideration whatsoever subordinate to itself. This is the right which must be at every cost pursued by myself and conceded to me by others, which dominates every action, lies at the root of all human progress, shapes every institution of our devising, and presides over the destiny of mankind to its remotest end. For, travel as far as we please, we can never escape from the conditions under which we were called into being.

So far, then, the task we set before us of ascertaining how the sense of rightness came into the world has been in some degree accomplished. The process by which from this prolific germ the vast fabric of human morality, together with the exquisitely delicate machinery of the individual conscience, as we now see it, has by slow degrees grown up, can be indicated in a sentence. Morality consists in transferring to other beings like ourselves those rights which we feel that we ourselves possess, in learning that what is due to us from them is also due to them from us, in ascertaining in what those mutual rights consist, in adjusting the rights of individuals within the limits of one society, lastly, in forming to ourselves notions of abstract right and wrong by the methods of philosophical inquiry. Manifestly, therefore, this account of the origin of conscience does not conflict with any one proposition that has ever been formulated by any of the great masters of experimental philosophy; it does but claim to add to them that undefinable something which seemed to the common-sense of mankind deficient in their account of conscience. The true method of inquiry is surely not to ask what such words as "conscience," "ought," "duty," "happiness," mean in the mind of a modern thinker, but to discover, if we can, what they meant, or rather to what instinctive impressions they corresponded, in the minds of the forefathers of our race. For the question is *not* "How did I come by my conscience?" but "How did those remote ancestors of mine, the first man and after him the first society of men, come by theirs?"

The history of the process by which, under the influence of social life, its wants, obligations, utilities, arrangements, and sanctions, the sense of a right due to ourselves was elaborated into the voice of conscience prescribing what is due to others, would be a valuable and interesting contribution to moral science. But though quite beyond our present limits it is, I think, possible to sketch in mere outline the stages through which conscience passed till it reached its full growth. I disclaim any pedantic desire to show that these stages are chronologically successive; on the contrary, they act and react upon each other, and may be immensely varied in their operations among different races or at different times. But with this proviso the seven ages of conscience may be briefly indicated as follows:

1. The Animal Stage. Mr. Darwin's book has familiarized us with the idea that the moral and mental elements in man's nature, no less than the physical and material, were derived from irrational creatures by the process of evolution. How far this is capable of being proved in other respects it is not for me to say (whatever I may believe), but I am sure that it is true of that element which seems at first sight most opposed to it—the conscience. Making all allowance for the temptation and tendency to read our own thoughts into the minds of animals, and also for the effect upon the animals themselves of man's moral control, it yet remains certain that the materials out of which conscience has been constructed are everywhere discernible, like the rough unhewed stones of a quarry, in animal life and in Nature itself. The mere fact that animals can be taught and made to feel what they ought to do (how can we avoid using the word "ought?") settles the question. But, without relying upon this, is it not evident that the contrast between the external force that *would* destroy and the internal power that *will* live existed long before it became an object of perception and reflection in the brain of a reasoning creature? And this contrast produced such actions as the following—flight, combination for defense, appealing looks, cries of remonstrance, self-defense to the last moment of existence. For instance, the sight of an object accustomed to prey upon a weaker animal then and there stimulated that animal to immediate flight by putting into motion the appropriate muscles and limbs. But the animals with which man is in closest alliance were those whose weakness must certainly have made the necessity of escape a large part of their experience. With this would come a great number of painful and also pleasant emotions. The need of horrible exertions, the terror of anticipation, the sense of unavailing wrath, sometimes the ecstasy of deliverance, which must have been so strong in the heart of every hunted animal that turned to bay at last, are seen to border closely upon that instinct of rightness which so evidently belongs to our individual inherited experience. It needed but the touch of self-consciousness to make the instinctive feeling pass by a bound into an instinctive thought in the mind of a being that "could look before and after." And whatever difficulty there may be in accounting for the evolution of man lies not in his moral but in his mental growth. How he became conscious of himself we may possibly never be able even to imagine, but that being conscious of himself he was by mere force of circumstances possessed of the germ of conscience, is a statement that presents no difficulty at all.

2. The Intermediate Stage. What was the moral condition of the "ape-like man?" He was a creature who had a vivid and intense conception of his own right to exist, and no conception whatever as to the rights of other creatures to the same existence. He was the inheritor of conditions and tendencies which wrought in him such thoughts as these: "You shall die before I will;" "I will use you to please my-

self;" "I am born to pursue my own happiness;" "The whole world is mine to occupy, plunder, and rule over, so far as I find a power within me to do it and to prevent others." He was, in short, the incarnation of perfect selfishness. No one, of course, supposes that these "thoughts" amounted to anything more than vague impressions in the minds of the first men, till they grew into positive convictions under the fostering power of progressive and multiplied experiences. All that seems certain is, that there was an era in the history of man when there was added to his nascent conscience that sense of physical or necessary obligation expressed in our word "must." If he was to avoid destruction, it was borne in upon his mind that he "must" act in such and such a way; his perception of right, that is, of his claim to existence, demanded of him a certain course of action (hardly yet perhaps of conduct), and demanded it in the most brief and imperative fashion. In this stage of human life, before men entered into social relations, we can plainly discern that aspect of conscience which we have described by the word "instantaneous," and which has seemed to so many minds independent of, and prior to, any social experiences. We do but reproduce this ancient fashion of our race when, putting aside all opposing considerations, and refusing to listen to arguments based upon expediency or advantage, we say peremptorily and decisively, "I owe it to myself to do this at once."

3. The Family Stage. The phenomena of primeval family life are so obscure, so varied, and so complicated by institutions like polygamy and polyandry, that in making even the most general and apparently common-sense observations we are obliged to express ourselves with caution and reserve. One indubitable fact, however, stands out impressively amid all the chaos, and affords us a sufficient standpoint for indicating the precise growth of conscience at this stage of its existence. I mean, of course, the maternal care of offspring. It was from this deeply-rooted instinct that men first learned to transfer to the beings whom they loved, and whose helpless weakness appealed to them for protection, the same rights which they claimed for themselves. But however important and indeed enormous is the step thus made in the evolution of conscience, we must beware of making too much of it at this stage of its growth. For the first parents, even when preserving and protecting their children, could only regard their children's rights as part of their own, which they were entitled to defend against all opposing forces; nor could they possibly have imagined that their children had any rights as against themselves. Still, when every deduction has been made, the fact remains that the sense of an obligation due to others besides ourselves, and perhaps too from ourselves, became part of the human consciousness, and men learned that if they wished to do well unto themselves they must make efforts of care and protection for the life and for the welfare of others. All the earlier annals of our race seem to show that this consideration for others, even those dearest to

us, was at first but a very flickering and transitory feeling as opposed to our inherited selfishness; but, for all that, it was the bridge by which men first began to cross from self-love to benevolence, and to become social beings. An interesting survival of this primeval state of things may perhaps be traced in Roman law, under which the father's control over his children seems to point back to the time when men did their duty to their children only as part of themselves, and exercised to the fullest extent the right to do what they pleased with their own. A less pleasing reminiscence of the primitive conscience is to be found in the plea of the slaveholders, that they do not ill-treat their slaves because it is for their own interests to keep them alive, healthy, and happy.

4. The Social Stage. At a certain period of his mental growth primeval man must have begun to form conceptions or ideas of the various objects that came within his experience, so as to be able to say, "This is a flower, and this a stone, and this a man." Now his idea of man must of necessity have been framed upon his knowledge of himself. Whatever qualities or properties he recognized as belonging to himself, these he would transfer to all other beings of whose likeness to himself in all essential conditions he had become aware. Hence it would follow that as he had a distinct and vivid impression of his own right to existence, he would have the same impression, in a faint and dubious form, of other men as possessing the same right. It seems probable that to this rudimentary perception of mutual likeness may be traced all that part of our social feelings which owes its origin to an intellectual as opposed to physical sources. Anyhow this recognition of likeness selects for man the kind of beings with whom he is willing to enter into those social relations to which he finds himself impelled in part by inherited instincts, and in part by the necessity of living together with other creatures in the same territory, and upon the same means of subsistence which they must procure in common. Thus the important fact emerges that man brought (in germ) the idea of right and wrong with him to the formation of society, and did *not* obtain it as a result of social intercourse acting through the agency of pains and pleasures. From the moment that A, B, and C, recognizing a likeness of nature, and therefore a possibility of intercommunion, resolved upon trying the experiment of living together, they must have perceived that they could only do so by acknowledging each other's independent claims to be allowed to live. In respect of all that pertains to life and death they must, in short, have acted up to what Mr. Mill called the "golden ethics" of doing to others as we would they should do unto us. Let us note, in passing, that this "golden" saying, when seen in the light of evolution, becomes not merely a moral rule but also a statement of a scientific fact, for it was only by acting in accordance with it that "neighborhood" became possible. "Who is my neighbor but he to whom I assign the same right to exist that I claim for myself from him?"

We are now in a position to describe how man came by that social *modus vivendi* which we call utility, and define as all that makes for the continued existence and progressive welfare of the community. Utility is scientifically "*the result of the conflict of individual rights, with survival of the fittest.*" The first right that passed away was the right to kill my neighbor; the first that survived was the right that my neighbor should not kill me. And to these rights conscience paid an intuitive deference (rendered perhaps all the more striking by the contrast presented by men's habitual practice) from the moment that the mind conceived the possibility of social relations. Things being as they were, it could not do otherwise. But then this right to one's self soon passes, under the fostering nurture of social life, to mean not merely bare animal existence, but all that conduces to make life happy, free, good, and useful. During the long course of advancing ages, rights are being conceded to the individual or being abandoned by him according as experience shows what is possible and best for human life and happiness. And all the while the conscience plays its part in this upward progress by transferring to any recognized reasonable rightness (alas! also to a thousand wrongs, which, yet true to its innate origin, the universal conscience persists in regarding as doomed to pass away) the same intuitive deference that it could not help but pay to the first moral inference evolved by the needs and the instincts of social life, "If you have no right to kill me, then have I no right to kill you."

5. The Political Stage. The earliest and (in a certain sense) most authentic records of the human race represent the murder of a brother as the first crime, the murderer's fear of vengeance as the first idea of punishment, and "Whoso sheddeth man's blood by man shall his blood be shed" as the first effort of criminal law to curb the murderous instincts. We have in this a very impressive representation of the next stage in the history of conscience. At first the faint and shadowy idea of my neighbor's right to existence must have been a poor and frail defense indeed against the storms of innate passion, the cruel, selfish lusts, the reckless and savage assaults of men just emerged from the animals and beginning a social life, which, unlike theirs, involved a conscious sacrifice of the individual's will to the community. But no society could have lasted for long without there growing up a distinct and profound conviction that the indiscriminate taking of life cut at the root of its own existence. There are many interesting (in a scientific sense) survivals (blood-feuds, for instance, or the cheapness of human life, which invariably accompanies the dissolution of society at revolutionary epochs) of this primeval state of man, during which some of the strongest sentiments we possess were engraved upon our mental and moral constitution by the external action of laws and customs. It was now that the voice of the community began to proclaim in no hesitating tones to the individual conscience "Thou shalt not kill," and to take

very decisive steps indeed to make its decrees heard and obeyed. And so the word duty began to be in the air.

Now, I hold it to be quite impossible that any such external command could create in the mind the sense that it is a matter of duty to obey it; nay, all law must have presented itself to the individual merely as part of that very external force which was originally, and is still liable at any moment to become, the natural enemy of his personal rights. And if I (that is to say, my ancestor of thousands of years ago) am merely forced by laws acting upon my fear of punishment to surrender my desire to slay another man, I may of course yield to superior force, but I cannot possibly thereby acquire the sense of duty, which may be defined as *the pleasure resulting from intelligent acquiescence in self-sacrifice that makes self-sacrifice possible.* But when the law appeals to a sense of right and wrong already existing, when the command "Thou shalt not kill" is met by a response in the conscience, "I know that this is true, for I had the thought before, or rather at the moment when, I became a social being," then there results the joyful sense of duty which makes obedience pleasant. "Wherefore," the conscience cries, "the law is holy, and the commandment holy, and just, and good." It is welcomed as the interpreter of conscience, as that which explains a man to himself. And so through countless avenues of utility, and through as many sanctions of social opinion embodied in law, custom, or tradition, the conscience advances toward the perception of the rights of men and of a corresponding internal sense of duty toward them. And thus, as I think, we get an explanation of the pleasurable element in duty. For while the law is becoming more and more imperative, and sacrifice of self more and more exacting, and our personal rights more and more circumscribed, there goes along with us the sense that we are but finding our true selves and expressing our own convictions and obeying our own highest wills, and are thus enabled to experience the greatest possible delight in doing our duty. For what is this, after all, but the satisfaction of finding our life when we were willing to lose it?

6. The Ideal or Moral Stage. The next step in the history of conscience carries us a long way forward in the course of man's mental evolution, because it brings us to the time when he became capable of forming abstract notions. But it must be borne in mind that long before these notions were formed, the tendencies and impressions in which they culminated were busiiy, if silently, at work; hence it is possible to trace the line of advance along which the conscience passed from the primitive sense of rightness to the complete ideal state.

It is natural for men, under the pressure of social obligations, to fall back upon their personal rights and innate egoism, and to question the authority to which they have submitted more from a gregarious instinct than from any exercise of their reasoning powers. Questions like the following lie deep down in the nature and necessity of things, and ex-

ercise powerful effect upon the mental and moral modes of thought long before they become articulate in language: "Why am I restricted from doing what I please? Why does law or custom pronounce it wrong to kill one man, right to kill another? Why would my fellow-men think it right to kill me under certain circumstances? Why is the law on this and other points so unfair, so irregular, so incomplete, that were I to fashion my conduct by it alone, I should be always doing something of which I did not approve? Above all, am not I, the unit of which society is composed and for whose benefit it exists, in danger of losing my right to myself and becoming merged in a mere aggregate mass of my fellow-units? Is right and wrong to be determined for me without effort or remonstrance, or even coöperation of my own?"[1]

Now the answer which man has made for himself to such questions is, by common confession, the discovery and the assertion that there is an absolute rightness belonging to society as such, with which individual rights may be harmonized, but which they can never supersede. How did he come to make this discovery and assert it with so unhesitating a conviction? Of justice in the abstract (for this is what we call the social rightness) it is true that primitive man could have no conception; that idea has been generalized from experience. Now we have seen that the first man was dominated by the consciousness of a primitive rightness due to himself. We have seen also that, compelled by the instincts of forming a social life, he extended the same rightness to individual men like himself. We are now to see that, under the stress of questions such as the above, and strengthened by the growing power of forming general ideas, the mind transferred to society, to Nature, nay, to inanimate matter, the same idea of absolute rightness which it claimed for itself. Man perceived right everywhere and in all things just as he had done at first—*then* in the simple concrete form of the right to his own existence, *now* in the highly-abstract form of everything having its own right and wrong. At first all Nature is indebted to him, now he is indebted to all Nature. Utility prescribed in what right and wrong consisted, but did not give the idea of it; or, to speak more accurately, if we are willing to define utility as that which makes for the existence of anything, then just as utility or the needs of his own existence had suggested to man the idea of primitive rightness, so did it impress upon him the idea of rightness as inherent in the constitu-

[1] The relation between the power of law in enforcing rights and the power of conscience in detecting rightness is well illustrated by a sentence of Sir Henry Maine's, describing the action of English law upon Indian modes of thought: "Unfortunately for us, we have created the sense of legal right before we have created a proportionate power of distinguishing good from evil in the law upon which the legal right depends" ("Village Communities," lect. iii.). I may add that the history of village communities presents a curious illustration of the way in which the conflicting rights of egoism and society were preserved in early times, i. e., by what would now be considered an exaggerated expression of them side by side. *See* his remarks on the isolation of households and the secrecy of family life, in the fourth lecture.

tion of things, and especially of society, if it were to continue to exist. Men come to think that they have no business wantonly to destroy anything, not even an insect or an inanimate object. Yet if they do it at all, they answer that it was because it was "useless." It is thus by tracing ideas apparently dissimilar to the same root that we obtain the strongest possible confirmation of the truth of our contention.

It was thus, then, that men began to form to themselves moral ideas, having an absolute and universal existence as opposed to the mere passing dicta of laws and opinions. In the special case before us the inference ran thus: "If it is not right for me to kill, then all killing is naturally wrong, necessary exceptions notwithstanding." And thus the ideal was formed of the sanctity of human life, and society was regarded only as a means for this end, all its arrangements and institutions being of necessity submitted to the moral judgment of the individual mind, and approved only so far as they came up to the ideal. It must, indeed, be confessed that there are survivals from earlier stages of moral growth which cast a strange and ironical reflection upon man's claim to wisdom and advancement, and cause his practice to fall lamentably short of even so early and obvious an ideal as the sanctity of life. How else are we to account for the fact that while all England will thrill at the news of some specially savage murder, or while we ourselves would be saddened to the end of our days by the result of some homicidal carelessness, we yet contrive to read morning after morning without a sigh or even a passing remark of battles in which thousands of human beings have perished for a cause in which they had no more real concern than they had for the politics of the planet Jupiter?

It was thus, then, that men embarked upon that process of forming ideals which led them from the primitive thought, "Self-preservation is the first (and only) law in Nature," up to the highest abstract expression of moral duty, "Fiat justitia, ruat cœlum." But now observe the immensely important influence which the formation of ideals exercised upon the moral constitution. It was this which enabled men, amid the pressure and conflicts of life, to vindicate their primeval claims to themselves, and to establish an independent moral existence in the midst of society, as they had at first established an independent physical existence in the midst of the universe. The immediate effect was that they became a law unto themselves. For instance, under the influence of such an ideal as the sanctity of human life, they refuse to kill even when authority commands them; nay, they prefer themselves to die. That is to say, the original claim to bodily life reappears in the form of a claim to moral life, to which we insist that the same deference shall be paid as our forefathers claimed for their natural existence, and which, thanks to the innate law of our being, we refuse to surrender upon any conditions whatever. And thus we have come to understand what is meant by the significant phrase, "rights of conscience." Can it be said that this has been satisfactorily explained up to the present time?

Mr. Herbert Spencer finds the origin of the sense of justice to self in the egoistic sentiment known as the love or instinct of personal freedom. Carry the analysis one step further back, to the innate demand for personal existence, and, like finding a diamond in a coal-mine, we come upon just that element of absolute, all-pervading, essential rightness for which we might otherwise search in vain.

No wonder, then, that men have almost deified the power they possess of discerning right and wrong, to which they owe in the last resort the possession of themselves. But, unhappily, egoism is easily overdone, and egoism, identifying itself with liberty and duty, is liable to all kinds of mischievous exaggerations and delusions. Conscience comes to be regarded as a special faculty instead of being an ordinary operation of thought directed to special objects. It is ascribed to a divine origin and erected into a test of religion and truth. The chief stress of practical exhortation is laid not upon finding out the right, but upon doing what we believe to be right, very often irrespective of advice, common-sense, and obvious consequences. Nay, men go so far as to assign to conscience a sort of lordship or supremacy over themselves, and so, by a roundabout way, only end at last in doing what they please. Like Arthur, they "reverence their conscience as their king," and, like that excellent but unprosperous monarch, they contrive, with the best intentions in the world, to make a bad business of life. In short, they glorify not the sun which gives the light, but the eye which perceives it, and thus give rise to a reaction against the pretensions, nay, the very existence of conscience, which causes whole volumes of philosophy to be written with barely so much as the mention of its name. To redress the balance, recourse must be had to the good genius of philosophy—evolution.

7. The Religious Stage. I have placed this stage last because the association, much more the identification, of religion with morality comes so late in the history of man, that religion has but little to do with the conscience in its elementary state. Among savages, religion can hardly be called moral at all, although the gods might, on the whole, be believed to be on the side of what the tribe thought to be right—subject, however, to the very important qualification that the gods of another tribe held different views. Still, so far as primitive man believed that the gods would visit him with rewards and punishments by an exercise of superhuman power, to that extent there was added to the conscience a feeling of responsibility and solemnity together with an awful imperativeness which must have considerably modified his moral constitution. Moreover, by calling attention to a will external to our own, something was done to counteract the egoistic tendency which I have just described. And so it was that morality did not take final refuge in stoicism until religious belief had died away.

The truth, of course, is that religion can and does become definitely moral when the human mind rises to a belief in one Almighty God with

whose will righteousness is of necessity identified. How the Hebrew branch of the Semitic family came by this belief (along with other peoples who, however, did not retain it) cannot at present be positively affirmed, but it is of exceeding interest to observe that the earliest idea of the moral will of God is connected with the instinct of self-preservation, to which we have traced the genesis of conscience. What in other races is the voice of tribal opinion condemning murder, is, among the Hebrews, regarded as the voice of God, "who at the hand of every man's brother will require the life of man." In this we see how records, old in themselves, and pointing back to tendencies and traditions lost in the mists of antiquity, identify the primitive rightness with the will of God, by whom first Nature, then man, then the family, then the society, had been established. And thus the will of the Creator has been by degrees definitely set up as the standard of right and wrong to which men must conform, so that the supreme effort of human morality is breathed in the prayer, "Thy will be done." And this accounts for the remarkable fact that the idea of conscience had little or no hold upon the Jewish mind. Modern theology bases religious belief mainly upon a supernatural origin of the conscience and a supernatural revelation as to the conditions of the future life. The Bible, for all practical purposes, has nothing to say about either of them.

To sum up, then, the result of our investigation, the conscience which we now possess is the primitive sense of a rightness due to one's self, resulting from the struggle for existence; extended to others as men entering into the social state perceived a likeness to themselves in their fellows; intensified and sanctioned by the urgent pressure of external law in the political state; becoming a law to itself as men became capable of forming abstract notions; and saved from egoism by the Christian development of the Hebrew monotheism.

Now the truth and adequacy of this statemant may be tested in two ways: Is it conformable to what we know to be true of evolution generally? and is it in harmony with the phenomena presented by the conscience now? It has been impossible to do more than here and there indicate an answer to the second question; but if opportunity offered it would be, I believe, easy to answer it at length by an examination of the operations of conscience in actual practice, and by surveying the conflicting forces, the curious survivals, the metaphysical theories, with which the word conscience is associated. Anyhow, the history of the conscience from an evolutionist point of view remains yet to be written.

But is this theory of its origin in harmony with evolution itself? How far, for instance, are we justified in using such words as "think," "say," "feel," or "law," "idea," and "consciousness," in describing the moral condition of primitive man? To this we must reply that the inchoate tendencies and slowly-deepening impressions which finally culminated in the phenomena described by words like the above, pre-

sent an inward and personal aspect of the nature and progress of evolution which ought not to be overlooked. For the very method and circumstances of man's creation by evolution planted within him a consciousness from which, when acted upon by myriads of slowly-widening experiences, were evolved all the fundamental powers of his moral nature. Let us illustrate this position by the cognate example of the genesis of religious beliefs. These were developed, let us say, either from the worship of ancestors, or (according to the mythological theory) by personifying the operations of Nature. But it seems to me totally impossible that any merely external cause could have produced a belief so primitive, so powerful, so universal, so permanent, and above all so strongly marked by certain original and undeviating characteristics, unless they had been correlated with the consciousness of a creature in whom by the very law of his origin the Spirit of Evolution was always suggesting an unanswerable question: "Where wast thou when I laid the foundations of the earth? declare, if thou hast understanding." Primitive man had enough of philosophy to ask this question, and enough of science to attempt to answer it out of such materials as lay ready to hand; hence it is that speculations as to their own origin are common, if not universal, among savage races. As in religion so in morality. All the external impressions arising out of society, law, utility, and the like, were related to and conditioned by an innate sense of rightness in the individual, wrought in him by the power of evolution itself by which he was created. And thus we arrive at that inward and SPIRITUAL side of evolution to which I have endeavored to call attention, in the belief not only that justice remains yet to be done to it, but also that it contains a reconciling and adjusting element much needed amid the conflicts and misunderstandings of modern thought. But from the further pursuit of this thought I am obliged, however reluctantly, to turn away.—*Nineteenth Century.*

CIVILIZATION AND SCIENCE.[1]

By Professor EMIL DU BOIS-REYMOND,
of the University of Berlin.

PART III.

VIII.—Prussian Gymnasium Education in the Struggle against the Progress of Americanization.

HOW are we to guard our youth against this debasing influence? The answer appears to be easy, and has often been given before. Let us set up the palladium of humanism against that natural science which would subject to dissection our ideals, which contemptuously re-

[1] An address delivered before the Scientific Lectures Association of Cologne. Translated from the German by J. Fitzgerald, A. M., and carefully revised by the author.

jects whatever it cannot bring into the cold light of reason, which would divest history of its profound interest, and would even tear away the veil which adds to the charms of Nature. As humanism rescued man from the prison-house of scholastic theology, so let it enter the lists once more to battle against the new enemy of harmonious culture. The gods and heroes of antiquity, with their immortal fascinations; the myths and stories of the Mediterranean nations, in which, as we might say, is enshrined all that is good and beautiful; the spectacle of a civilization which subsisted, it is true, without natural science, but out of which prominent men rose to a mental greatness hardly ever attained since—it is from the action of such influences as these upon the mind of youth that we can most confidently hope for victory in the struggle with the neo-barbarism which, though as yet its hold upon us is loose, is, from day to day, tightening its iron grasp. It is Hellenism that must ward off from our intellectual frontier the onset of Americanism.

But is it, then, possible to bring our youth into more intimate and more stable contact with classic antiquity than heretofore? In our old and tried gymnasia have we not most careful provision made for this very thing? What other country can boast of imparting so thorough and so learned a classical education, and that to so large a proportion of its youth, even of the less wealthy classes? Other enlightened countries of Europe have their eminent university professors, but the profoundly-erudite, unassuming, and hard-working *Oberlehrer* is a German type, of which the nation may well be proud. Thus not only do we hold the foremost rank in gymnasial education, but we even, in all probability, have reached the limits of the possible; and were there no other means of staying the decline of German idealism, save by increased study of Latin and Greek in the gymnasia, we could have but little hopes of checking the downward tendency.

It will now seem paradoxical for me to assert that more Latin and Greek certainly will not, but that perhaps a little less of them might, insure this result. In fact, if our gymnasia are not to promote Americanization, instead of counteracting it, I hold that certain reforms of the plan of study are imperatively necessary.

The gymnasial education of the youth of Germany, like the constitution of the army, exerts an enormous influence on German life. The gymnasium has gradually come to possess a simply despotic power over the family. For every educated citizen, therefore, who has himself made the gymnasium course, or who has sons in the gymnasium, it becomes a right and a duty to concern himself about the organization of those schools. Doubly is it his right to do this if, belonging to a learned profession, he has had opportunities of observing the results of gymnasium education. This is the case with myself. As a professor in the university, not only am I in constant relations with students in the early semesters, and frequently, through my public lectures, with those who are not studying medicine, but also, for upward of twenty-five years, as

examiner for the state and for the Faculty, I have learned more or less accurately the educational standing of some 3,000 young men who had left the first class of the gymnasium from two to four years previously.

But there is a special reason why I should express my views about the organization of gymnasia. In 1869 the rectors and senates of the Prussian universities were invited by the Government to report on the question "whether and to what extent the pupils of the Realschulen[1] could be admitted, as well as those of the gymnasia, to the faculty courses of the universities." As being at that time Rector of the Berlin University, it fell to my lot to draw up the report of its senate. Not merely as reporter of the senate, but also with the warmth of personal conviction, I pronounced against the admission of the realschulen pupils, and took all pains to inculcate the importance of classical studies, for which nothing else could be substituted. In harmony with the senate, however, I even then insisted that, in taking sides with the gymnasia against the realschulen, one is not bound to look on the former as perfect—i. e., as not susceptible of, or not requiring, reformation in one point or another.

If I had now again to make a report in the same sense, I should find myself embarrassed. My opinion as to the advantages imparted by classical training is unchanged. My objections to making the pupils of the realschulen the peers of those of the gymnasia are as strong as ever. But the conviction has ever been growing in me that our present gymnasium education is no sufficient preparation for the study of medicine, nay, that as viewed from a general standing-point, it does not quite perform the task which it has proposed to itself. Hence I could no longer justify the exclusion of the realschulen pupils, at least from the medical classes, unless certain reforms were granted in the gymnasial plan of studies. Inasmuch as formerly, when placed in prominent position, I maintained a different opinion, I consider myself under a sort of obligation publicly to state my change of views, and to give the reasons therefor. Should that report come up for discussion in the course of the debates upon the education act, which we suppose will soon be laid before the Parliament, I, for my part, do not wish to be held answerable for it any longer. For the rest, of course I abstain here from an exhaustive discussion of this subject, and purpose simply to indicate in brief the direction in which I should like to see our gymnasial plan of studies modified.

I regret that, in the first place, I have to state an impression which has been steadily growing on me, that the humanistic education of the average medical student is, with us, sadly defective. Such is their unfamiliarity with Latin etymology, such the poverty of their Latin and Greek vocabularies—for instance, many of our medical students, a few years after passing the maturity examination, are unable to trace to their source Greek technical terms—that we can only conclude that

[1] Industrial schools.

these evidences of defective scholarship were glossed over at the time of the examination by some mechanical contrivance. How far these young men were familiar with the personages, the thoughts, and the forms of the ancient world, whether they had any sense of our dependence on the ancients, and of our being their intellectual descendants —for that is the sum and substance of humanism—I of course have had no opportunity for determining. Nor did I get any systematic information of their historical knowledge. However, their indifference toward broad ideas and historic sequence makes it difficult for me to believe that they are permeated with the spirit of antiquity, or that they had received a sound historical training.

To all this I must add another deplorable fact. For the most part these young people wrote in ungrammatical and inelegant German. Owing to the unsettled state of our orthography, our word-formation, and our construction of sentences, instruction in the mother-tongue is more difficult among ourselves than among people who have a settled usage in language. But the young people, as a rule, did not even suspect that any one could care about purity of language and pronunciation, force of expression, brevity, or pointedness of style. One is ashamed, as a German, of such barbarism as this, knowing what care instruction in the mother-tongue receives from the French and English, in whose eyes an infraction of its rules appears to be, as it were, a sacrilege. The more closely this blemish in our educational practice is connected with a deep-lying national defect, the more is it to be wished that the gymnasia had been successful in removing it. This neglect of the mother-tongue is, in the youth of the present day, accompanied by a lack of acquaintance with the German classics that is oftentimes astounding. Time was when, in Germany, no one any longer quoted from the first part of "Faust," because quotation had been overdone. Is the time now coming when it can no longer be quoted, because no one would understand the allusion?

With respect to instruction in mathematics, I know that but few masters succeed in advancing all their pupils equally. Clearly there are minds highly gifted in other respects, but to which mathematics is a book with seven seals. I would only remark upon the mathematical programme prescribed by tradition and convention for the highest class in our gymnasia. In a semi-official plan of studies this programme is given as follows: "Geometry of solids, with mensuration of surfaces and volumes; geometrical and stereometrical problems; problems in algebra, particularly in its application to geometry; indetermined equations; continued fractions; the binomial theorem." Though under "problems in algebra, particularly in its application to geometry," analytical geometry might be included, that branch is omitted from the gymnasial plan of studies by a ministerial decision of ancient date, but still in full force, and the mathematical programme of the highest realschulen surpasses in this respect that of the gymnasia.

Now, this I hold to be a serious error. The influence of mathematics as an educating force is not fully exerted till the student passes from these elementary studies to analytical geometry. No doubt, even simple geometry and algebra accustom the mind to strict quantitative reasoning, and to assuming as true nothing but axioms or demonstrated propositions. But the representation of functions by curves or surfaces opens a new world of ideas, and teaches us the use of one of the most fruitful methods whereby the human mind has increased its own powers. What the invention of this method by Viète and Descartes was to mankind, that will initiation into it still be to every mind that has any turn for such studies—namely, an illumination marking an epoch in life. This method has its roots in the profoundest depths of the human intellect, and hence is of far higher importance than the most ingenious analytical processes which are applicable only to a particular case. True, trigonometry is analytical geometry; as taught in the gymnasia, trigonometry, like stereometry, as both these terms indicate, has to do rather with mensuration, and its use is restricted to a certain class of problems. On the other hand, between any two quantities whatsoever, of which the one can be regarded as dependent on the other, there never exists a relation so complicated but that it may be represented by a curve; of this fact Quetelet has furnished an instructive demonstration—as, for example, where he represents by curves criminal tendency, literary talent, etc. This mode of representing the mutual dependence of things is of as much advantage to the government functionary and the political economist as to the physicist and the meteorologist.

But in medicine it is indispensable. In the preface to my "Untersuchungen über thierische Elektricität," which bears the date of March, 1848, I spoke in commendation of it as a means of bringing mathematics to bear on physiology, even in cases where the complexity is so great as to preclude the possibility of measuring, of weighing, or of calculating time. I then first laid an absciss-axis in a nerve, while Ludwig made the blood-circulation itself trace in curves its variations of pressure, and Helmholtz made the muscle in like manner trace its own contractions. Nowadays, thanks mainly to the labors of Marey, there is scarcely any department of experimental physiology or pathology that does not yield, through the graphical method, results of high importance. But, as our students of medicine may have quit the gymnasium without ever having so much as heard of a system of coördinates, I am compelled, at the opening of my lectures on physiology, to make my hearers acquainted with the elements of analytical geometry.

From the reasons assigned for the above-quoted decision of the ministry, whereby conic sections are excluded from the gymnasium course of study, it is plain that its author was unacquainted with the general scope of the branch of science he put under ban, and that he considered

it as too difficult for the *prima*.[1] This is a mistake. On the contrary, there are minds which, though highly gifted, and of a philosophical turn, yet lack the sort of subordinate attention that is necessary in order, for instance, to carry out a long trigonometrical calculation, and which find themselves much more at ease in analytical geometry. The fact that analytical geometry prepares the way through the differential and integral calculus to the last and highest aims of mathematics, and hence to their most difficult portion, should only form one reason more for beginning the study of it in the gymnasium. And, not to pass by unanswered an objection which might be raised, I would remark that, owing to the flourishing state of mathematical instruction in our universities for a long time past, the present masters of mathematics in the higher classes of our gymnasia are, almost without exception, qualified to teach analytical geometry, and would even be glad were they authorized to teach that branch. Many of the highest living authorities in this department share in the views which I have here expressed. Then, too, in several gymnasia of non-Prussian Germany, analytical geometry is already taught.

I will not now dwell on the fact that the freshmen in our medical classes, who, in the course of their studies, and later, in the practice of their art, have to depend largely on a right use of their senses, bring from the gymnasium only a very defective training in this respect. I omit the consideration of this, because we have not to do here with the medical student as such, but only in so far as he typifies the student in general; and I take him as a type because my observations on the work of the gymnasium are based principally on the results seen in him. Here the question arises, whether the gymnasium attains its end better in the case of students belonging to the other faculties. To a certain extent it does. With those who later devote themselves to the intellectual sciences, natural disposition and home-surroundings will oftentimes be more favorable to humanistic studies than with those who are impelled by hereditary realism toward medicine and the investigation of Nature. Besides, students of theology and jurisprudence are more favorably situated for retaining their humanistic culture than are students of medicine, who from their first semester have to do with a world of things which have no connection, save through their terminology, with classical studies. Hence the average degree of humanistic culture among medical students is a very good test for determining how far the gymnasium is in a condition to oppose the encroachments of realism.

But even when we take into account all the youths who receive a gymnasium education, however diverse their tendencies as regards branches of study, we do not find in them so quick an interest in classical studies as would justify us in seriously expecting from it a reaction in the idealistic sense. Not reckoning philologists, who of course are not within the scope of our remarks just now, there are but few stu-

[1] Highest class in the gymnasium.

dents, indeed, who in later years ever open an ancient author. So far from having any warm love for the classics, most persons regard them with indifference; not a few with aversion. They are remembered only as the instruments by means of which they were made familiar with the rules of grammar, just as the only conception they retain of universal history is that of learning by rote insignificant dates. Was it for this that these youths sat for thirty hours weekly on a school-bench till their eighteenth or twentieth year? Was it for this that they devoted most of their time to studying Greek, Latin, and history? Is this the result for the attainment of which the gymnasium remorselessly englooms the life of the German boy?

In view of this state of things, we ask whether everything is going on aright; whether it is not time, and whether it is not worth our while, to make an effort at reform? Here as elsewhere it is easier, especially for outsiders, to find fault than to determine how to repair the defect. Here, as is so often the case in complicated questions of administration and of human life in general, there are many causes in operation. We take into consideration one, while ten others of no less importance escape unnoticed. Still, though I expose myself to this danger, I will not refrain from expressing my views.

Without meaning any offense to the distinguished men who have taken an active part in organizing our gymnasia, or who are still so engaged, I cannot conceal my conviction that the spirit of the gymnasium does not sufficiently keep pace with the development of the human mind in modern times. As is evident from what has already been said, I am fully alive to the perils with which our intellectual culture is threatened by an excess of realism. At the same time, we cannot shut our eyes to the fact that natural science has given a new aspect to human existence. We should be imitating the ostrich in burying its head in the sand were we to deny the mighty revolution described above, and it were a vain and perilous thing to try to stop the rolling wheel of such a process of development. But hitherto the gymnasium has not taken this development sufficiently into account. Despite a few concessions, which are apparent rather than real, it is still what the Reformation made it, when as yet there was no natural science—namely, a learned school essentially designed as a means of preparing for the study of the intellectual sciences.

In this backwardness of the gymnasium and its refusal to comply with the demands of the time lies the strength of the realschule. I do not propose to enter here on the intricate question of the competencies proper to each of these two kinds of institutions. For the rest, I agree with the views of those who desire only one species of higher schools, which should fit their pupils equally for the university, the industrial or architectural academy, the army, etc. Plainly, this would be simply the humanistic gymnasium transformed so as to meet these new requirements. Apart from measures of administration, all that is needed to

put an end to the rivalry of the realschule is, that the gymnasium should sacrifice to the needs of the time some of its time-honored but antiquated claims, and conform itself somewhat more to the tendencies of the modern world. So soon as the gymnasium becomes imbued *bona fide* with a new spirit, and insures fitting preparation even to those who devote themselves to other than intellectual sciences, this rivalry will cease of its own accord. The much-mooted question of the admission of realschulen pupils to faculty classes would thus be settled, for then the realschule would revert to its original intent, and be an industrial school—an institution of great importance in its proper sphere.

What, then, do I demand of the gymnasium so that it shall appear to meet the requirements of the time? Essentially, very little, indeed. First, I demand more mathematics. The mathematical course must include the discussion of equations of the second degree, and a few other plane curves, and must also give an introduction to differential calculus through the theory of tangents. To this end, a greater number of hours must of course be given to mathematics—six or eight, instead of four. In the examinations for advancement and graduation, mathematics must really stand on an equality with the ancient languages and history. The equality of the teacher of mathematics with the teachers of the other branches would in this way be made an actual fact.

It will now, perhaps, be expected that I will further demand a large increase in scientific instruction. But I do not at all purpose to convert the gymnasium into a school for science-teaching. All that I ask is that as much shall be done to meet the wants of the future physician, architect, or military officer, as those of the future judge, or preacher, or teacher of classical languages. Thus, I ask for only so much natural history in the lower classes of the school as will awaken the faculty of observing, and that facilities be given for familiarizing the lads with the method of classification, which is rooted in the depths of the understanding, and whose educational force is so eloquently described by Cuvier. Let Darwinism, of which I am myself an adherent, be excluded from the gymnasium. In the higher classes, for the reasons assigned in my report, I should like to have taught, not physics and chemistry with experiments, but mechanics, the elements of astronomy, also of mathematical and physical geography—to which studies one hour more than heretofore could be devoted without injury.

But how are we to find time for these innovations? In the *prima* two hours might be gained by doing away with the religious instruction. We cannot understand the use of such instruction in a class whose Protestant pupils have all been confirmed; and yet, in the semi-official plan of studies already quoted, more than half a page of fine print is expended in setting forth the subject-matter of this instruction, while five lines suffice to dispatch the mathematical programme. On reading this half-page and the corresponding half-page for the upper second class, one imagines he has before him the programme of a theological

seminary. Even with the best intentions, it is not easy to see how "the reading of the Augustan Confession in connection with instructing in the differences between various symbols of faith" can form part of the general culture which it is the object of the gymnasium to impart to its pupils.

My second scheme for giving more room to mathematics and natural science will probably seem more objectionable, at least to a larger circle of people, than the first. I dare hardly express it, but I would restrict the study of Greek grammatical forms. My enthusiasm for the beauties of Grecian literature is assuredly not less than that of any German schoolman. But, unless I am greatly mistaken, the proper aim of studying Greek—namely, acquaintance with Grecian myth, history, and art, and being imbued with Greek ideas and Greek ideals—can be attained without the unspeakable labor—mostly labor in vain—which it costs to acquire the power of putting together a couple of Greek phrases. Surely neither Goethe when he wrote his "Iphigenie," nor Thorwaldsen when he modeled "The Triumph of Alexander," could write a Greek composition such as is written by the pupils in the lower second class of our gymnasia. If there is one Greek author whom all pupils read understandingly, and even with enthusiasm, and whom many of them hold dear and commit to memory, it is old Homer. And yet Homer's dialect is so different from that in which the *extemporalia*[1] are written that the practice gained by such exercises is of no account as far as his works are concerned. Hence without written exercises one can acquire such mastery of a dead language as is needed in order to read the authors who have written in it; and, as Homer, so, too, might the great Attic masters of style be read, the written exercises being restricted to preparation and translation. On a former occasion I gave utterance to the heretical opinion that our German style has been impaired by too extensive a study of the Greek. For exercising the intellectual faculties, and for awakening and developing a sense of the fundamental properties of a good style—namely, correctness, precision, and brevity of expression—there is no doubt that Latin with its limpid clearness, its rigorous precision, and its absolute definiteness of meaning, is a better object of study than Greek with its multitudinous forms and particles, the import of which is matter rather of skilled conjecture and artistic feeling than of logical analysis. Since the time when our system of gymnasium education assumed its present shape, our knowledge of the ancient world has undergone an almost entire transformation: barren philology has become the living science of that defunct world, and even daily our store of pictures of ancient life is enlarged by successful excavations. To one not versed in the study of pedagogy it would appear as though wonderful results might be attained here, just as in natural science, by the *demonstratio ad oculos*. Such a one is inclined to think the pupil would, by studying copies of antique

[1] Off-hand compositions.

works of art, in a few hours imbibe more of the true Hellenic spirit than he could by listening ever so long to dissertations on the aorist tense, the subjunctive and optative modes, and the particle ἄν.

In the teaching of history, the course of instruction which often loses itself in unimportant details—as, for instance, the party struggles of ancient Rome, or the rivalries of emperors and popes in the middle ages—I should like to see more fully illustrated than is usually the case, with general views of the state of civilization, exhibiting the heroes of science, literature, and art. The mass of very unprofitable dates which the young are required to commit to memory seems all the more pitiable when we remember that these pupils are suffered to remain ignorant even of the existence of the most important constants of Nature. Can it be that a knowledge of the date of an agrarian law, or of the accession of a Salico-Frankish emperor, is of more importance for a liberal education than is a knowledge of the combustion-heat of carbon or the mechanical equivalent of heat?

I have not time to enter on the question of the modern languages in the gymnasium. Besides, to me it appears to be a matter of greater moment to find out how we can secure for pupils in the gymnasia more thorough instruction in the mother-tongue. As I have already remarked, we have here to do with overcoming a national defect. But to discuss this point more fully here would carry us too far away; besides, I have already discussed it elsewhere.

So far I have spoken only of my own wishes. But I do not stand alone. I know of a large number of eminent men who share my views. Under the banner with the motto "Conic sections! No more Greek compositions!" I am sure I could assemble a meeting for gymnasium reform which would be formidable for the amount of intellect which would be there represented. I am very glad to find myself, as regards every topic of importance, in accord with my colleague, Prof. Adolph Fick, of Würzburg, who quite recently has written a paper entitled "Considerations on Gymnasium Education."

It were rash to attempt to penetrate the future in so complex a matter as this. But, in conclusion, to come back to the train of thought which led us up to this practical question, it appears to me that in such a reform of the gymnasium as I have here indicated is to be found the best security against the inroads of realism on our intellectual culture. The transformed gymnasium, again harmonized with the requirements of the period, will for the first time be fully equipped for the struggle with realism. Instead of burdening its pupils with classical studies till they turn from them in disgust, rendering them insensible to the charms of the Hellenic spirit, and giving them an aversion to humanism by the torturing drill in pedantic forms; instead of violently giving to their ideas a direction which sets them at variance with the world around, the gymnasium will insure to them an harmonious education in accordance with modern ideas. While based on an

historic foundation, this education will at the same time embrace the elements of modern civilization in due measure. By itself giving free play, within certain limits, to realism, it will be all the better enabled to resist its encroachments. By yielding a little of its own, it will insure the safety of all the rest; and thus perhaps it will defend—if it is not already too late—the nation's treasure which has been intrusted to it, German idealism.

ARTIFICIAL PRECIOUS STONES.[1]

By CARUS STERNE.

ONE day, not long ago, the jewelers of Paris were in a high state of excitement, and justly so, for the news had reached them from the Academy of Sciences that two chemists, MM. E. Frémy and Feil, had discovered a process for the manufacture by the pound of certain kinds of precious stones ranking in value next to the diamond, and frequently commanding still larger prices than the latter—namely, the ruby, the sapphire, and the most precious of all, the Oriental emerald. At first the Parisian jewelers consoled themselves with the thought that the genuine stones would always be preferred to the artificial ones, but the excitement increased when it became known that MM. Frémy and Feil did not propose to imitate precious stones, but that their productions would be perfectly equal to the natural ones, and that a watch would run on their artificial rubies as well as on natural ones, because both of them were equally hard. Now the dealers in precious stones asserted that it was sinful to imitate Nature's work in that manner, and that the Government ought to prohibit it. On the other hand, a few enthusiastic *feuilletonistes* proclaimed that the discovery in question foreshadowed a still more important one—that of making gold and diamonds; that the dreams of the alchemists were about to be realized, and that poverty and wretchedness would be no more.

Of the prospect of poverty and wretchedness coming to an end we say nothing here. As for the transformation of lead and other base metals into gold and silver, we have to declare that this branch of alchemy is something altogether different from the manufacture of precious stones. Most of our modern chemists hold metals to be simple, immutable elements, which have always been what they are now, and which may change their form, but never their peculiar nature. Not so with precious stones, most of which, and especially those that are most highly prized, are of very lowly origin indeed. In the eyes of the chemist the ruby, the sapphire, the topaz, etc., are simply modifications of one substance (alumina), which, as *clay*, forms the greater portion of the earth's

[1] Translated from the *Gartenlaube*.

crust; and the diamond, which is the prince of all precious stones, is simply pure crystallized carbon, and so allied to charcoal, lampblack, etc. Other highly-esteemed precious stones, such as the emerald, the aqua-marina, and chrysoberyl, on the one hand, and the hyacinth, on the other, contain "earths" chemically related to argillaceous earth—namely, the former consist of beryl-earth, and the latter of zirconia; but these earths in themselves are neither rare nor precious, so that in some countries the streets are paved with the impurer brothers of the emerald. The same is true of all other precious stones, including pearls; in the main they are formed of substances of no value whatever, and to be found everywhere, such as argillaceous earth, silicic acid, fluor-spar, boracic acid, lime, magnesia, etc. Their only superiority consists in the fact that the common substance in them has reached an extraordinary degree of crystallization, for, aside from their beauty, their rarity enhances their value in the market.

Chemical combinations and simple substances of mineral as well as of organic nature assume their due crystal shapes, which are so well defined as frequently to bear a strong resemblance to those of cut stones, only when they pass from the liquid into the solid state, and they assume a large size only when this transition takes place very slowly. For instance, if we dissolve in hot water as much alum as can be dissolved therein, and suspend in the fluid, while allowing it to cool in a quiet place, a wire vessel—a basket, a rosette, or a crown, wrapped in wool—we shall find next morning that wire vessel covered with glass-like, transparent, more or less large, glittering octahedral crystals. Cold water is unable to hold in solution as large a quantity of the salt as warm water; and the surplus, as the temperature of the water decreases, has to separate slowly from it. In so doing, small crystals are formed. They grow constantly as the separation goes on, and, if we leave the solution exposed to the fresh air so that it slowly evaporates, we shall at last obtain very large crystals. If the alum contained an impure admixture of other salts, they would remain in the water. Crystallization, as a general thing, is also a purification of foreign admixtures.

In all probability, in Nature many precious stones have formed in the same manner; and most mineralogists concur in the opinion that rock-crystals, consisting of nothing but silicic acid, and frequently weighing hundreds of pounds, have originated thus. It is almost certain that this formation from liquids into solid bodies has taken place in a large class of half-precious stones, such as quartz and pyrites, consisting likewise of nothing but silica—namely, agate, jasper, opal, chalcedony, chrysoprase, carnelian, heliotrope, and others.

At the same meeting of the Parisian Academy where MM. Frémy and Feil described their process of manufacturing artificial rubies and sapphires, M. Monnier stated that he had obtained artificial opals by pouring a highly-diluted solution of oxalic acid cautiously upon a

solution as thick as molasses of silicate of soda, which brings about a slow separation of the silicic acid. When, in so doing, he used a solution of the sulphate of nickel protoxide, he obtained apple-green stones, such as the chrysoprase. Thus we see that, as long as the process of separation lasts, we may talk of the growth of precious stones; and we perceive, from the laws of crystallization, how by the attraction of similar parts, and the exclusion of foreign ones, the formation of precious stones of perfectly "pure water" among the more impure ones, which are frequently found, becomes more intelligible.

Another process of crystallization is the slow cooling of molten substances. This can be explained very strikingly to students of chemistry if a kettle of sulphur or molten bismuth is cooled slowly, until it is covered with a crust of congealed matter, so to speak. Pierce that crust in the middle, and pour out a portion of the liquid, and there will form on the walls of the cavity thus created crystals of surpassing beauty, and the whole assumes the appearance of a so-called crystal druse, a form often assumed by amethysts and other half-precious stones. It has been thought that, to make artificial diamonds, it was necessary only to melt coal; but, unfortunately, the results thus far obtained are of no value.

Nature's most successful way of producing precious stones was not to dissolve minerals, but to put them into a fiery liquid condition, and to separate the new productions slowly from their former impure parts by chemical and electric influences, as we shall see directly. The earth, like the sun and most fixed stars at present, was undoubtedly formerly in a fiery, liquid condition. Then the elements were commingled; all substances met, and entered the strangest combinations; the whole globe was an immense chemical laboratory. The earthy substances with the light metals, at the last period of those gigantic processes, probably formed the "mother-liquor," from which, under various chemical agencies, there separated now valuable metals, now grains of gold, and still more frequently substances which were ennobled by crystallization. The "mother-liquor," cooled with its productions, we call primitive formations—granite, feldspar, porphyry, etc. It may here be stated that these primitive processes have recently been imitated in part, and that two principal components of feldspar, albite and orthoclase, have lately been obtained from a fiery, liquid mixture of minerals.

Precious stones so formed would be colorless if, in the terrible furnace of the primordial world, fire-proof metals had not taken upon themselves the task performed by aniline in our present dying-works. Long before there were colored plants and animals, metals played the part of pigments in Nature, and thus produced, in stones, colors almost surpassing in brilliancy those to be found in the animal kingdom. Rubies and emeralds are probably colored with chrome, sapphires with cobalt, lapis-lazulis with iron, and other precious stones with copper, nickel, manganese, etc. But we only have to refer our readers to the

magnificent windows of Gothic cathedrals, with their gorgeous colors, produced by combinations of metals in the molten state. The false precious stones made in Paris with so much perfection from heavy strass-glass are colored with metallic oxides in as lasting a manner as the genuine stones.

The first precious stone reproduced, not only in its appearance, but its real nature, and in all its component parts, is the lapis-lazuli, the sapphire of the ancients, not to be confounded with the sapphire of our modern jewelers. This untransparent stone, of a magnificent azure-blue color, was most highly prized by the ancient Hindoos, Assyrians, Persians, Jews, Egyptians, Greeks, etc.; and this irrefragably refutes the erroneous theory of some archæologists that the ancients were unable to distinguish the blue color. When pulverized, this stone furnishes the surpassingly beautiful ultramarine color with which the artists of the middle ages delighted to paint the mantle or gown of the Virgin Mary, although they had to pay the most extravagant prices for the pigment, which they always charged in the bills of those who had ordered a sacred picture from them. Some fifty or sixty years ago, Gmelin, the German chemist, discovered that this most beautiful of blue colors could be artificially produced by heating argillaceous earth with soda, sulphur, and carbon; and now that Guimet, the French chemist, has practically introduced this process, Europe manufactures annually about 100,000,000 pounds of this pigment, most of which is produced in Germany.

At a very early period chemists devoted their attention to the artificial reproduction of rubies and sapphires, which, as we have said before, consist of nothing but crystallized argillaceous earth, colored by minute particles of metals. Several decades ago, the chemist Gaudin succeeded in obtaining small ruby pellets from pure argillaceous earth, precipitated from dissolved alum and moistened with chromate of potash. The color of these rubies, according to the quantity of chromate which they contained, was either that of a rose or bordering on purple. The pellets were so hard that they easily cut glass, garnets, and topazes; but they were not crystals, and their transparency was by no means perfect. Similar experiments were made by the chemists De Bray, Sainte-Claire Deville, Caron, Sénarmont, Ebelmann, and others. It was long acknowledged that a crystallization of argillaceous or beryl earth had to be obtained, and to that end it was necessary to reduce them with the requisite quantities of the coloring metallic combinations into a state of fiery liquefaction. Boric acid was selected for that purpose, because when heated it slowly evaporates. It appears as vapor in volcanic countries, and is especially obtained in Tuscany. The belief that this fiery means of reduction had played in Nature a part in the formation of precious stones was perfectly justifiable; and so boric acid was placed in comparatively large quantities with argillaceous or beryl earth in open platinum crucibles, which were subjected to a long-con-

tinued heat in porcelain furnaces. In fact, as soon as the larger portion of the boric acid has evaporated, there are evolved from the fiery, liquid mass small rubies, sapphires, or emeralds. This was discovered some twenty years ago, but the crystals were too small to make the process a remunerative one.

Far more satisfactory were the results of Frémy's recent experiments. They are based upon a different principle, namely, that of separating the argillaceous earth slowly from its usual combination with silicic acid, as it is found in Nature everywhere, by bringing to bear upon it a substance of stronger affinity for the acid. In consequence, small crystals of argillaceous earth are formed in the fiery, liquid "mother-liquor," which, in the course of further separation, grow slowly. In the glass-factories of M. Feil, quantities of this "mother-liquor" of precious stones, weighing from twenty-five to fifty pounds, were easily kept in a fiery, liquid state for two and three weeks, and in this way very favorable results were obtained. The most advantageous process turned out to be the separation of the argillaceous earth from the silicic acid by means of oxide of lead, for which purpose a mixture of equal parts of pure porcelain-clay and red-lead was placed in a large crucible of fire-proof clay and exposed for weeks to an intense red heat. Usually, the lead also extracts the silicic acid which the walls of the crucible contain, and eats holes through them. Hence, to avoid losses, the precious-stone crucible should be placed in another.

After several weeks of patient waiting, vividly recalling the expectant watching of the old alchemists at their crucibles in which the philosopher's stone was to be created, the crucible is taken out and cooled. After destroying the crucible, the contents are found to consist of two strata, above a glassy one, consisting principally of silicate of lead, and below a crystalline one, containing the most beautiful crystals of argillaceous earth in round clusters. If nothing but argillaceous earth and red-lead has been placed in the crucible, these crystals are as colorless as glass. They will cut glass and rock-crystal, nay, even the very hard topaz; in short, they are precious corundums or diamond-spar, so called because, next to the diamond and crystalline boron, it is the hardest of all stones.

Now rubies, sapphires, and Oriental emeralds, are nothing but colored corundums, and the former two can be easily obtained by the addition of the requisite quantities of the coloring metallic combinations. When there was added to the mixture of argillaceous earth and red-lead two or three per cent. of bichromate of potash, the crystals showed the beautiful rose-color of the ruby; when only a small quantity of that salt was used, and simultaneously a still smaller quantity of oxide of cobalt was added, sapphires were obtained. The precious stones thus produced, as a rule, are covered with a firm crust of silicate of lead, which is best removed chemically by melting it with oxide of lead or potash, or by means of hydrate of fluor-spar. Among a number of pounds of

such crystals of argillaceous earth which the inventors submitted to the Academy, there were numerous pieces that could not be distinguished at all from natural rubies and sapphires. They possessed their crystalline shape, their weight, hardness, color, and adamantine lustre, although the latter was not altogether faultless.

How completely the imitation of Nature has succeeded, may be inferred from a peculiarity which the artificial rubies have in common with the natural ones: both, upon being heated, lose their rose-color, and do not recover it until they are cooled again. The diamond-cutters who were requested to grind these artificial rubies found them not only as hard as the natural ones, but in many instances even harder; they were not long in blunting their best tools made of the hardest steel. For the use of watch-makers they are, perhaps, better than the natural stones.

But jewelers, too, are certain, sooner or later, to derive a great deal of benefit from these discoveries. The rubies hitherto obtained, although very beautiful, did not equal the first-class natural stones; but they are only the first productions of a new process, and it is decidedly creditable to the inventors that they immediately divulged their method without trying to mystify the public. Now others, too, may follow up this new branch of a promising alchemy. Perhaps more time should be given to the crystals for their formation, for Nature had a great deal of time for such productions, and it was owing to this fact, perhaps, that it achieved such glorious triumphs. There can be no doubt but that, at some future time, these crystals of argillaceous earth will be colored also green, yellow, and purple, and that thus the precious stones, which were hitherto distinguished as Oriental emeralds, topazes, and amethysts, from inferior stones of the same name, will be produced. The addition "Oriental," in this connection, has no geographical meaning, and was applied by jewelers to the harder and better classes of emeralds, topazes, and amethysts. Perhaps these Oriental stones will be cheaper at an early day than the inferior ones, and the middle classes may wear as brilliant stones as princesses do now.

Diamonds, too, were the objects of similar processes, that is, by trying to bring about a slow separation of carbon from its combinations. However, Chemistry has to admit here that it cannot demonstrate, with any degree of accuracy, how Nature really produced the diamond. Some think that it could only have been formed at an enormously high temperature; others consider its very slow formation in a cold condition more probable; nay, there are scientists who regard it as the production of some organic agency, because there are frequently discerned in them green, cellular formations resembling certain algæ. In view of the rapid progress of synthetic chemistry, it might, perhaps, be as well for the diamond to maintain even in the eyes of chemists its time-honored name "adamas"—that is, *the indomitable one*. For what should the

"fine lady" wear in the future if the prince of precious stones should follow the example of those standing closest to its throne, and allow itself to be reproduced for a few shillings?

THE TEREDO AND ITS DEPREDATIONS.[1]

By Dr. E. H. VON BAUMHAUER,
COMMISSIONER TO THE CENTENNIAL EXHIBITION FROM HOLLAND.

II.

CONTRARY to the opinion of Sellius, who regarded the teredos as hermaphrodites, Quatrefages has taught us that they are of both sexes and that the ratio of males to females is about one to twenty. The females are oviparous. The eggs are expelled by the branchial siphon: Quatrefages found them in that siphon and in the branchial canal itself. The mode of fecundation is, however, unknown; it is supposed that, in that act, two different teredos project their siphons and bring them in contact.

As regards the metamorphoses which the eggs undergo, either in the branchial tubes or in the water, nothing has been added to what was made known through the researches of Quatrefages in 1849. That naturalist has taught us that the eggs pass through the series of modifications, from the starting-point, which one meets with in the examination of all animals—i. e., the formation of the germinative area and of the vesicle of Purkinje, the disappearance of this and the breaking up of the vitellus. The eggs undergo their development in the branchial cavity of the mother; the embryos resemble very small, rounded animalcula of vesicular form, and are provided with vibratile cilia, by the aid of which they have regular movements, and probably are expelled from the branchial cavity into the siphon. In a third phase of development the bivalve shell is formed, the foot appears on the outside, the vibratile cilia form a sort of crown, and the embryo thus possesses the faculty of locomotion as well by creeping as by swimming. The development of the eggs takes place from time to time, and especially in the month of June, although even as late as the 29th of July Harting found eggs in all the teredos which he opened. The development of the eggs progresses very rapidly; in four days they pass out of the embryonic state, fully equipped for living in wood. Toward the end of June, Kater observed them in large numbers on the surface of wood, and by the 15th of July he found them in the interior in the form of perfectly-developed teredos. Even in the month of December, but no later, he saw young teredos enter into pieces of wood placed by

[1] Extract from the "Archives of Holland," vol. i., translated by Edward R. Andrews.

design in the water; at that time they were from eight to fourteen days old, and, although very small, they resembled in every respect older teredos.

Teredos penetrate wood naturally by very small openings in a direction perpendicular to the surface (Figs. 12 and 15, *C*); then they generally turn about in order to follow the direction of the woody fibres, usually upward, but sometimes downward. Although they do not enter into the earth or mud, one generally finds the first traces immediately above the line of the mud in which piles are driven; it is at this point that piles destroyed by the teredo generally break off.

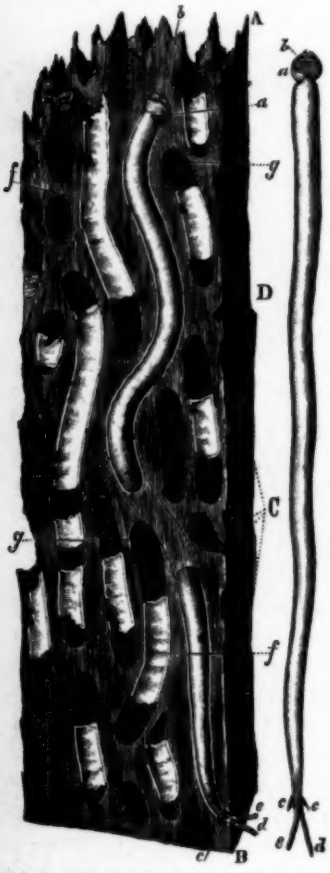

FIG. 12.—Wood exposed from November, 1874, to September, 1876, in crib at Pier No. 1, New York, North River, twenty-five feet below mean low tide.

When the teredos are lodged in a piece of wood, one recognizes them by very small holes on the surface, and the extremely delicate tubes which project from them (Fig. 12, *e*, *d*). These are the siphons, only one of which shows at first, the other appearing later. These siphons are generally kept outside the wood in the water, but the slightest touch causes the animal to retract them. One of them is shorter and larger than the other, but they both seem to serve for the expulsion of the fæces, which largely consist of particles of wood reduced to a very fine powder. It is known that the teredo does not perforate wood for nourishment, but only to procure a suitable abode; the woody substance, detached in the boring, passes through the intestinal canal, and then is expelled in the form of a very fine white substance by one of the siphons, generally, according to M. Vrolik, by the shorter, but sometimes by the longer. The long siphon appears to serve principally for the introduction of food, which consists of infusoria, diatoms, and other inferior animalcula, which the sea-water brings with it into the siphons. It is nevertheless still uncertain whether the matters expelled through the longer siphon come directly from the intestinal tube, or if they are first introduced from outside with the inflowing water to be expelled again after a short sojourn inside.

The teredo requires for respiration a clear, pure water. It has often

been remarked that piles placed in dirty, muddy water, near drains, for example, are protected thereby. The water should have, moreover, a certain degree of saltness; the teredo cannot live in brackish water; that is a point to which we shall return later.

The teredo continues to grow in the wood; while the gallery which it forms presents near the surface a diameter of only one-quarter to half a millimetre, it enlarges little by little, until it reaches a diameter of five millimetres and more; as regards his length, and consequently that of the tube which incloses him, we have sometimes found it to be thirty to forty centimetres. He never goes upward more than half-way between the flow and ebb of the tide; although the teredo is thus, for a short time, partially above the water, yet it appears that the wood holds a sufficient amount of moisture to sustain his life temporarily.

The researches of Kater have still further shown, what had already been remarked by Sellius, that the teredo can hibernate in the wood, and that it is those individuals, thus preserved, which in the spring go through with all the phenomena of reproduction—i. e., the formation of eggs, fecundation, development, and expulsion of the young.

The part of the external integuments which constitutes the mantle deposits a calcareous matter, forming an interior lining to the gallery in the wood (Fig. 12, *f*); between this calcareous casing and the body of the animal there remains a space sufficient to prevent any inconvenience, at least during the act of respiration; for it is possible that when the teredo absorbs water, which serves for respiration, his body is distended, and fills exactly the calcareous tube. The form of this tube, secreted little by little, corresponds exactly with that of the gallery, which has been slowly perforated in the wood; it has the appearance, also, of a series of rings placed one against the other. As the animal progresses, a new ring is added to those which existed before, so that when the tube is closed at its extremity by a calcareous film, its length represents the total length of the animal (Fig. 12, *b* to *c*). Among the segments of the tube, those which are nearest the surface of the wood are the oldest and hardest; in the interior of the wood, where the gallery ends (Fig. 12, *g*), the calcareous ring, newly formed, is at first soft, flexible, and of slight consistency; later, it becomes solid, and closes up the tube, as has been remarked by Sellius. In the variety of teredo described by us, we have never observed the formation of two openings surrounded by calcareous matter, situated side by side, like an eight placed sidewise, ∞,[1] and serving as a passage for the siphons, as described by Deshayes.

The calcareous tube, once formed, constitutes for each teredo his own abode, where he isolates himself from his companions, and has nothing to fear from their close proximity. One never sees a teredo pierce the tube of another. The tubes make their way side by side,

[1] Some Oriental varieties have this form. I have seen them at the Boston Institute of Technology, with solid tubes one and a half inch in diameter.—TRANSLATOR.

and cross each other in every direction, but, be the wood ever so worm-eaten, there always remains a woody wall, often very thin, it is true, between two adjoining tubes.

The very existence of the adult teredos seems dependent upon the wood. Withdrawn from their galleries and placed in sea-water, they could be kept alive by Kater scarcely more than three or four days. Left in the wood, but taken out of sea-water, they would die within twenty-four hours. Deprived at the same time of contact with wood and sea-water, they perished at the end of one or two hours. In damp wood, that is, wood soaked with salt-water, their existence is prolonged somewhat. Wood and sea-water are, then, both necessary. If these two conditions of existence are furnished them, one can, Kater assures us, keep them alive during several months.

The teredo does not always remain in peaceable enjoyment of the home he has constructed, and the nourishment the water brings to him. He finds himself exposed to the attacks of an enemy, of an annelide to which the late M. W. de Haan has given the name of *Lycoris fucata* (Fig. 13). In our day, as well as at former epochs, this annelide is constantly found wherever the teredo exists. His eggs and embryos are met with in the midst of those of that mollusk.

FIG. 13.

Kater has remarked that the adult annelide, leaving the muddy bottom, where he has hibernated, and in which the piles are driven, climbs along the surface of the wood toward the opening made by the teredo; there he sucks away the life and substance of his victim; then, slightly enlarging the aperture, he penetrates and lodges in place of the teredo. Later the annelide reappears and seeks for new prey. All the early writers on this subject state that they have found this annelide in wood at the same time with the teredo. It is remarkable that a similar annelide, and perhaps the same, has been found in the cavities hollowed out in stone by the *pholades*.

It is important that it should be generally understood that this annelide is not only harmless, but renders the greatest service in devouring the wood-destroyer. It is a narrow annelide, ten to fifteen centimetres long, provided on his sides with a great number of small feet terminated with a point and garnished with hairs and showing in front a pair of strong upper jaws, horny and sharp, and lower jaws bent backward in form of hooks and carried outside by the aid of the lower lip, which is developed somewhat like the finger of a glove turned backward. Behind the head are four pairs of tubular-formed gills. With these weapons the annelide pursues and devours the teredo. The observations of Kater teach us that he is generally found in the empty galleries with the remains of the teredo; sometimes even he is seen as if clothed with the integuments of the teredo, while he is occupied in ransacking his intestines. Once Kater had the rare

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chance (which, by-the-way, only secures such good fortune to very careful observers) to seize the moment when an annelide, coming out of one of the openings of wood, at once took possession of a teredo that he had placed on the bottom of the vessel which held the wood. He saw the annelide seize the teredo with his jaws, draw him into the canal which he occupied, and devour him so completely that there only remained the two valves of the shell.

It is in an entirely different manner that the cirripeds (*Balanus sulcatus*) aid in preserving wood. When these animals, to which sailors and the inhabitants of our coasts give the name of *Pustules of the Sea*, or *Sea-Thorns*, multiply to such an extent on the surface of wood that their disks touch, without leaving the least vacant space, the natural consequence is, that the young teredo cannot find any place where it can attach itself, and hence it is impossible for him to penetrate the wood. This preservative effect is produced even when the shells have fallen, provided the disks adhere to the wood.

III.

On the Circumstances which favor the Ravages of the Teredo.—The commission gave in its first report an historical epitome of the injuries done by the teredo at different epochs in Holland.

When the teredo was remarked for the first time, an idea prevailed that it was imported from abroad; vessels coming from the East Indies were accused of having brought that destructive guest. Two facts show the incorrectness of this idea. On the occasion of the deepening of the Dumbart Dock at Belfast, William Thompson[1] found, twelve feet below the surface of the earth, in a blue, argillaceous soil, the trunk of a tree entirely riddled by the teredo. Considering the depth at which this *débris* was found, and the fact that it lay beneath a series of strata of shells, it is certain that it was deposited there ages ago, long before a vessel, coming from the East or West, could touch the coast at Belfast.

Fossil wood, perforated by the teredo, has been found in different localities: for example, in the London clay, in the Eocene formations at Brussels, where Van Beneden discovered fossil wood, inclosing the remains of the teredo; and at considerable depth, also, near Ghent, at the time of the construction of the citadel.

The teredo existed in a geological period earlier than our own, and he appears to have been always an inhabitant of our coast. Why is it, then, that at certain epochs, as in the years 1730, 1770, 1827, 1858, and 1859, he multiplied so prodigiously as to destroy entire dikes in a very short space of time? Even as early as 1733, Massuet assigned as a cause an increase of the degree of saltness of the water, resulting

[1] W. Thompson, on "The *Teredo navalis* and *Limnoria terebrans*," in Edinburgh *New Philosophical Journal* for January, 1855.

from a diminution in the quantity of the rainfall; the same opinion is found expressed in the reports of many chief engineers of Waterstaat. To decide whether this opinion was well founded, careful analyses were made in 1859, which, compared with those made at other epochs, showed that the proportion of salts found in the water of the Y was just double what it was in 1855, and a third more than in 1825.

. . . . . [1]

The three circumstances, under which this exceptional increase of the teredo was observed, were a moderate rainfall, and, as a direct or remote consequence, a falling of the level of the rivers, and an increase of the saltness of the water of our arms of the sea. As an additional favoring circumstance should also be noted an increase in the temperature.

FIG. 14.—This cut was made from a *Teredo navalis*, taken from a pile exposed two seasons (1876 and 1877) at Horn Island, Gulf of Mexico. When first taken from the wood it was eighteen inches long.

IV.

EXPERIMENTS IN THE PRESERVATION OF WOOD FROM THE ATTACKS OF THE TEREDO.—To justly appreciate the experiments tried by the commission, it must be borne in mind that when it was discovered, in 1858 and 1859, that great injury was being done to our marine works by the teredo, very many methods of preservation were recommended on all sides to the Government, and that the nature of many of these remedies was kept secret by the persons extolling them. In order that its labors should offer every guarantee of impartiality, and although convinced in advance of the inefficacy of a large number of the means proposed, the commission decided not to lay aside any without a trial. Moreover, as far as possible, it had the pieces of wood to be experimented with prepared by the inventors or proposers of the processes, in order to protect itself from every accusation of unfairness.

The experiments were made the first year in the ports of Flessingue,

[1] Several pages omitted, of no especial interest to American readers, describing local observations of the state of the water and atmosphere, and analyses of the waters, to show their chemical character.

Harlingen, Stavoren, and Nieuwendam, and afterward in the ports of Nieuwe-Diep and Stavoren. The woods employed were oak, red fir, ordinary fir, and *Pinus sylvestris*, generally in pieces one metre long by two or even three decimetres square. These blocks were prepared in different ways, and care was taken to place by their side blocks of the same kinds of wood without any preparation as counter-proofs.

The trials made by the commission may be placed under three principal groups:

1. Coatings applied to the surface of wood, or modifications of the surface itself.

2. Impregnation of wood with different substances, which modify the interior as well as the surface of the wood.

3. Employment of exotic woods, other than ordinary woods of construction.

COATINGS APPLIED TO THE SURFACE OF WOOD.—The methods belonging to this group, which have been examined by the commission, are the following:

1. Method invented by M. Claasen, and kept secret by the inventor.

2. Metallic paint, invented by M. Claasen and likewise kept secret.

3. Method of M. Brinkerink, consisting of a mixture of Russian talc, coal-tar, resin, sulphur, and finely-powdered glass, applied hot on wood previously roughened by a toothed instrument; this application was two millemetres thick.

4. Method of M. Rijswijk, analogous to the preceding.

5. Paraffine varnish, obtained by the dry distillation of peat, from the factory of MM. Haages & Co., at Amsterdam.

6. Coal-tar, applied cold on the wood in several successive layers, or applied hot on wood whose surface had been previously carbonized. Some pieces were treated as follows: Holes were first bored in them and filled with tar, then plugs were fitted closely to the holes and driven in with sufficient force to make the tar penetrate the wood; other pieces still were painted over with a mixture of tar with sulphuric acid, or sal ammoniac, or turpentine, or linseed-oil.

7. Painting with colors mixed with turpentine and linseed-oil—among others with chrome-green or with verdigris.

8. Singeing or superficial carbonization of the wood.

The pieces of wood thus prepared were placed in the water at the end of May, 1859, and the first examination, made toward the end of September of the same year, showed that neither of these methods afforded any protection from destruction by the teredo. There was one partial exception, and that was the pieces of wood treated according to No. 6; these showed only traces of the teredo here and there. But, at a later examination, in the autumn of 1860, when the wood had been exposed a year and a half, these were also found to be equally severely attacked by the teredo.

The results of these experiments strongly convinced the commission

that no exterior application of any nature whatever, or modification of the surface merely, would give any efficacious guarantee of protection against the teredo. Even supposing that one or another of these means would prevent the young teredos from attaching themselves to the wood, yet the constant friction of the water or ice, or any accident, might break the surface of the wood sufficiently to give access to the teredo.

This seems a proper place to mention a practice in general use in Holland for warding off the teredo: this consists in covering wood with a coat-of-mail made of nails. This operation is very costly; for, to really protect wood in this way, it is important that the square heads of the nails join exactly; for insuring the best results, the armored piles are exposed in the open air for some time before being placed in the water, that rust, forming on the surface of the iron, may close up the interstices inevitably remaining between the heads of the nails. But this precaution is not infallible, as the commission examined piles more than once, in the course of its investigation, which had been several years in the water, and whose surface was entirely incrusted with rust more than a centimetre thick, but which were, nevertheless, eaten in the interior by the teredo.

Sluice-gates are frequently covered by sheets of iron, copper, or zinc. It is evident that, so long as such covering remains intact, there is no cause for anxiety on the score of the teredo. Unfortunately, experience has taught us that this protection is not permanent, but is rendered ineffectual by being broken by the force of the water or blocks of ice.

Nature affords sometimes, as we have seen above, a more efficacious protection in covering wood with barnacles or other shell-fish, with the condition that this covering be made before the young teredo attaches itself to the wood. Facts of this sort have led Lehmann to propose the planting on wood of the common mussel (*Mytilus edulis*).

Impregnation of Wood with Different Substances. — The commission examined in this category the following methods:

1. *Sulphate of Copper.*—The impregnation of the blocks with this salt was performed at the factory of MM. Van der Elst and Smit, at Amsterdam. Experience proved, even in the first summer (of 1859), that this preparation had absolutely no power against the teredo. Nevertheless, to make sure that the failure of this experiment was not due to insufficient preparation, the commission procured from the establishment of M. Boucherie, at Paris, two pieces of beech-wood covered with its bark, two pieces of beech without bark, and two pieces of pine, all prepared with sulphate of copper. These blocks, when exposed, did not resist the teredo any better than those prepared at Amsterdam. These trials completely confirmed the results obtained by the engineer Noyon ("On the Inefficacy of the Boucherie Process in Sea-Water," *Annals of Bridges and Roads*, April, 1859).

2. *Sulphate of Protoxide of Iron* (*Green Vitriol*).—The blocks were

impregnated with this salt at the establishment of MM. Van der Elst and Smit. The first summer proved that this method would not in the least prevent the wood from being destroyed by the teredo. And the same was true of the following method :

3. *Acetate of Lead.*—The blocks impregnated with this salt were prepared at the same establishment.

Surprise may be expressed that the commission did not try experiments with corrosive sublimate. It felt that it could dispense with them, as its inefficacy had already been sufficiently established by previous experiments on a large scale at the marine dock-yards at Rotterdam. Experiments with mercurial and arsenical salts were tried, in 1730 and later, but without satisfactory results.

4. *Soluble Glass and Chloride of Calcium.*—Pieces of oak and red fir were impregnated at the same establishment at Amsterdam, first with a solution of soluble glass (silicate of soda), and afterward with a solution of chloride of calcium; the object of this double impregnation was to produce in the pores of the wood a silicate of lime. The pieces thus prepared were left in the open air during six months before being placed in the water, in order that the chemical combination might be as complete as possible. These pieces were exposed in the water at Nieuwe-Diep, in March, 1862, and

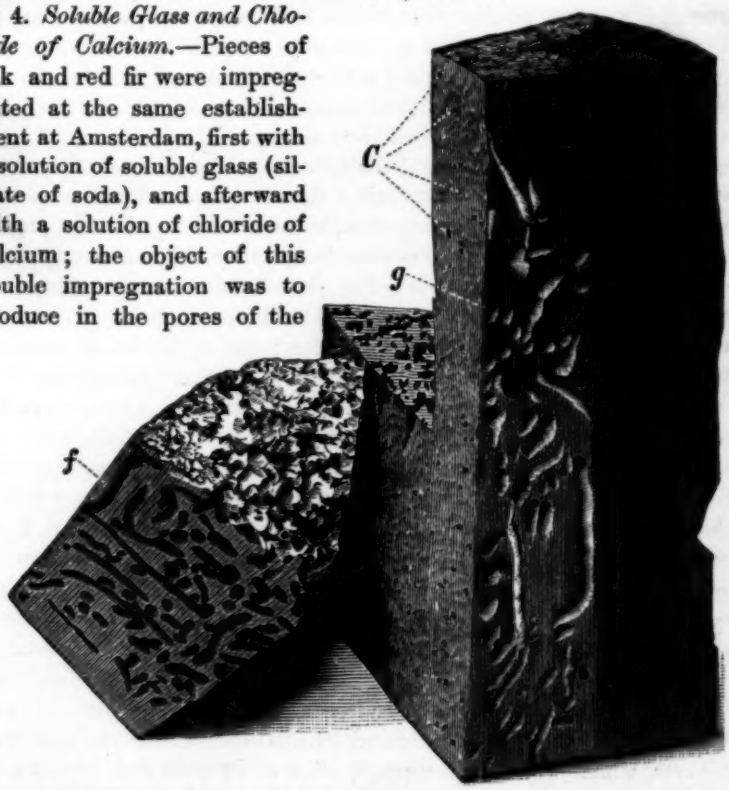


FIG. 15.—This cut was made from a piece of pine-slab, partially creosoted and exposed one season (1877) in the Gulf of Mexico. Only the dark-colored portion on the right side of the block was creosoted for this experiment. The rest of the block, *untreated*, was entirely riddled by the *Teredo navalis*, up to the edge of the creosoted portion, but that the destructive marine worm carefully avoided.

when withdrawn, in October of the same year, the preparation was found to be powerless as a protection against the teredo.

5. *Oil of Paraffine.*—The firm of Haages & Co., at Amsterdam, delivered to the commission some pieces of oak and red fir injected with a substance produced by the dry distillation of peat, to which they gave the name of *oil of paraffine.* In the month of July, 1860, the commission placed at Stavoren and Nieuwe-Diep ten pieces thus prepared. They were examined in the course of the same year, after they had passed one summer in the water, and it was found that they had resisted the attacks of the teredo.

The commission conducted all its experiments thus : They placed in the water ten pieces of each variety of wood, treated according to the prescribed method, so that they could withdraw each year, during ten consecutive years, one of the pieces to be submitted to examination. In making the examination, they removed with an adze the outside of the wood to a depth of some millimetres, which was sufficient to show the galleries of the teredos, if there were any. The pieces found intact were replaced in the water, and the following year their condition was tested in the same way, by removing the shavings as before. By this plan the commission felt certain that, if the blocks were not injured by the teredo during several successive years, they did not owe that protection to a superficial covering, but that the wood itself resisted the destructive efforts of the teredo, and that there would be no reason for fearing that piles, prepared in a similar manner, would, at any time, lose their power of resistance, when injured on their surface by water or ice, or by slow dissolution of the active principle of the preservative substance.

When the pieces of wood treated with oil of paraffine were taken from the water in 1862, after a sojourn of more than two years, or rather during three summers, traces of the teredo were found in the pieces of oak, but not on those of red fir; but when examined in November, 1863, fully-developed teredos were found everywhere, in the fir as well as in the oak, in the pieces whose surfaces had been removed by the adze, but not more than in those which had not been submitted to any examination.

6. *Oil of Creosote.*—This is, as is very well known, a product of the dry distillation of coal-tar, separated by distillation from the more volatile parts, which serve for the preparation of benzole and naphtha, the residuum being pitch. Experiments had already been tried abroad, as well as in Holland, with this substance, and from the beginning of their experiments the commission paid especial attention to this very important method of preparation.

Wood of various kinds, prepared with creosote-oil at the works of the Society for the Preparation and Preservation of Wood, at Amsterdam, was placed in the sea in the month of May, 1859, at Flessingue, Harlingen, and Stavoren. In the month of September following, at

Flessingue, the pieces of oak, pine, and red fir, were found intact, while those unprepared were perforated. In the month of October, of the same year, the pieces of creosoted pine and fir at Harlingen showed a perfect state of preservation. At Harlingen the treated and untreated pieces were fastened together; the teredo penetrated the latter, but had not touched the creosoted wood. The same was true of the creosoted wood exposed at Stavoren, when visited in 1859.

At Nieuwendam, in March, 1859, three pieces each of oak, pine, and red fir, all creosoted at Amsterdam, were exposed in the sea. They were examined in September of the same year. They had been fastened together by cross-pieces of unprepared wood: it was found that the teredo had penetrated, at the juncture of these cross-pieces, even into the creosoted wood, and that sometimes he stopped immediately beneath the surface, at others he penetrated to a depth of several millimetres; in the oak, he worked his way into the interior through those parts of the surface which were not in contact with the unprepared wood.

Experiments with creosote-oil were recommenced in July, 1860, with ten pieces each of oak and red fir, following the plan indicated in paragraph 5; the localities chosen were Nieuwe-Diep and Stavoren; in the latter place the pieces which remained intact the previous year were again placed in the water after their surface had been removed by the adze. Still later, in August, 1861, a further trial was made at these same places with pieces of pine, beech, and poplar, sent to the commission by Mr. Boulton, and prepared at his works in London.

All these pieces were examined toward autumn in 1862, 1863, and 1864; while the unprepared pieces, placed near the others as counterproofs, were found each year filled with teredos, one could not discover any traces of the teredo in the creosoted pieces except in the oak creosoted at Amsterdam; in cutting these, it was found that the creosote had penetrated them very imperfectly.

A third examination, in 1864, showed that all the pieces prepared by Mr. Boulton, and which had been exposed in the sea since August, 1861, were entirely intact; the most careful examination could not show the slightest trace of the worm, even in the pieces withdrawn from the water in 1862 and 1863, and each time scraped to a depth of several millimetres and again placed in the water. They resisted the attacks of the teredo perfectly.

An equally favorable and decisive result was obtained from the pieces of fir creosoted at Amsterdam. Notwithstanding they had been exposed in the sea since July, 1860, during five consecutive summers, nothing could be discovered which resembled the galleries of the teredo: one of the pieces, at a point where the color of the wood indicated an insufficient penetration of the creosote-oil, showed a very slight worm-eaten appearance; but the absence of the calcareous deposit, and

the whole character of the opening, indicated clearly that it should be attributed to some other animal than a teredo.

As to the unprepared pieces, there only remained small ends, which reached above the water. All the rest was converted into a spongy mass, which broke at the slightest effort.

The experiment with the creosoted oak was less satisfactory. In all the pieces were found, here and there, galleries of the teredo, but always in small numbers; in sawing the wood, it was found that the injuries were invariably in those parts where the color showed that the oil had not been able to penetrate. Although, as far as is known, no effort has been made elsewhere to preserve oak from the teredo, the commission places great value upon experiments with this wood. In fact, for many marine works, oak cannot be replaced by any soft wood which absorbs creosote-oil easily. Hence, the commission has had creosoted at Amsterdam, by a newly-perfected process, some pieces of oak, which were exposed in 1864 at Nieuwe-Diep; these will not be examined until tested during three summers.[1]

Petroleum has also been recommended to the commission, but it was not deemed worth while to experiment with it, especially on account of its high price; even although petroleum should prove to be as efficacious as creosote-oil for protecting wood against the teredo, its price would prevent its use for that purpose.

Experiments with Exotic Woods, other than Ordinary Woods of Construction.—The commission has not been able to make many experiments in this direction. It acquired a certainty that the greenhart of Surinam, the bulletrie, the American oaks, and wood as hard as *mamberklak*, are not spared by the teredo. The commission received a large piece of the wood of guaiacum, which had been five or six years in the water at Curaçoa, and was found to be entirely eaten by the teredo—an evident proof that even the hardest woods are not safe from the attacks of that mollusk.

The commission has received, it is true, many communications relative to different kinds of woods known to be poisonous to fish, but it has not had an opportunity to experiment with them. We await some light on this point, from researches which the Government has ordered to be made at our possessions in both the East and West Indies.

Conclusions.—By way of recapitulation, the results of the experiments, tried by the commission during six consecutive years, were as follows:

1. The different coatings applied to the surface of wood, with the design of covering it with an envelope on which the young teredo cannot attach itself, offer only an insufficient protection; these coverings are likely to be injured either by mechanical means, such as the action of the water, or by being dissolved by the water. Just so soon as

[1] American oaks of coarse, open fibre are easily impregnated.—Translator.

a point of surface of the wood is uncovered, be it ever so small, the teredo, still microscopic, penetrates into the interior. Covering wood with sheets of copper or zinc, or with nails, is a too expensive process, and only protects the wood so long as they form an unbroken surface.

2. Impregnation with inorganic, soluble salts, generally considered poisonous to fish and animals, does not protect wood from the attacks of the teredo. This want of efficacy must be attributed in part to the fact that the salts absorbed by the wood are extracted by the dissolving action of sea-water, and in part, also, because those salts do not appear to have a poisonous effect upon the teredo.

3. Although we do not know with any certainty if, among exotic woods, there may not be found those which will resist the teredo, we can affirm that hardness is not an obstacle which prevents that mollusk from perforating his galleries; the ravages observed in the wood of guaiacum and *mamberklak* prove this.

4. The only means which can be regarded with great certainty as a true preservative against the injury to which wood is exposed from the teredo, is the oil of creosote; nevertheless, in employing this means, care is necessary that the oil be of good quality, that the impregnation be thorough, and that such woods be used as will absorb oil readily.[1]

The conclusions arrived at by our commission are confirmed by the experience of a large number of engineers in the Netherlands, and also in England, France, and Belgium. M. Crepin, a celebrated Belgian engineer, expresses himself thus, in a report on experiments tried at Ostend, under date of February 5, 1864:

"The result of our experiments now seems decisive, and we think we can draw from them this conclusion: that soft woods, well prepared with creosote, are protected from the attacks of the teredo, and are in a condition to assure a long duration. The whole matter, in our opinion, is reduced to a question of thorough impregnation with good creosote-oils, and the use of such woods as are adapted to the purpose. It has been found that resinous[2] woods are impregnated much better than other varieties."

M. Forestier, a French engineer at Napoléon-Vendée, in a report dated March 3, 1864, makes a *résumé* of experiments conducted by himself in the port of Sables-d'Olonne, in the following words:

"These results fully confirm those established at Ostend, and it seems to us difficult to refuse to admit that the experiments at Ostend and Sables-d'Olonne are decisive, and prove in an incontestable manner that the teredo will not attack wood properly creosoted."

Under date of Haarlem, April 20, 1878, Prof. Von Baumhauer writes to Edward R. Andrews, of Boston:

"I have deferred answering your favor of the 22d of February until I had

[1] The efficacy of creosote-oil in protecting wood from decay and marine worms is largely due to the fact that it is insoluble in water.—E. R. A.

[2] The yellow pine of the Southern States absorbs oil very readily.—E. R. A.

corresponded with the chief-engineers of the Waterstaat as to the results obtained in their experience in the use of cresoted timber in all our marine works, in large quantities and during some tens of years. They all unanimously agree that the teredo will not penetrate timber thoroughly impregnated with creosote; but that, to obtain the best results, the work must be thorough, as they had observed that the teredo had destroyed piles only superficially injected.

"Fir, if the sap be first withdrawn in a vacuum and then treated with hot oils under a heavy pressure, can be most thoroughly creosoted; but oak is more difficult. Still, I have often seen heavy oak-piles where the creosote had entered into the very heart.

"Creosoted wood is also used in our country for railway-sleepers and tramways, and everywhere with the best results. They last four or five times longer than when unprepared, while experience shows that wood treated with sulphate of copper or chloride of zinc (Burnettizing) is neither protected from the teredo nor the influences of humidity and of the atmosphere."

SCIENCE IN THE ENGLISH SCHOOLS.

THE rejection of Sir John Lubbock's motion for the addition of elementary science, or, rather, as the matter was more happily put by Dr. Lyon Playfair in the course of the debate, of elementary knowledge of common things, to the subjects for which grants are given under the education code, although an inevitable and foregone conclusion, is not on that account the less to be deplored. As happens in many similar cases, the argument was all on the side of the minority, and Lord G. Hamilton, in opposing the suggestion on the part of the Privy Council, was only able to say that its adoption would, perhaps, entail some temporary uncertainty about the subjects in which inspectors would be required to examine and children to pass. If schools existed for the convenience of inspectors, or oven in order that children might not be troubled by uncertainties, the objection would have been a valid one; but upon any other supposition it seems to tell against, rather than in favor of, the contention which it was intended to support. The nation is spending large and rapidly-increasing sums of money upon schools, and it will every year become a matter of greater urgency that these sums should not be misapplied, either by the omission from the code of subjects which would be useful or by the inclusion of others which have no apparent tendency to promote the attainment of the ends to which education is supposed to be directed. These ends, in the case of a peasant-child, are presumably to render him a more useful and a better conducted member of society than he would become by the unaided light of Nature; and it is obvious that the means to their attainment are twofold—first, to cultivate the intelligence in such a way as to facilitate the acquirement and the application of knowledge; and, secondly,

to impart the knowledge which has to be applied. Until a comparatively recent time, however, the imparting of knowledge was considered to be the sole purpose of education, and to be in itself the best means of mental training; so that educationists occupied themselves more about the seed than about the soil, and were chiefly concerned to teach those things which they thought it most important that a child should know. The instruction given to the poor for many years was almost limited to reading, writing, arithmetic, and elementary religious instruction, while that imparted to the rich was laid upon the same foundation, and was only carried further because the pupils had more time at their disposal. In the employment of this time the instructors could only teach what they knew; the most famous public schools and the two great universities restricted themselves to giving their pupils some knowledge of classics and mathematics.

As soon as physiologists had discovered that all the faculties of the intellect, however originating or upon whatever exercised, were functions of a material organism of brain, absolutely dependent upon its integrity for their manifestation, and upon its growth and development for their improvement, it became apparent that the true office of the teacher of the future would be to seek to learn the conditions by which the growth and the operations of the brain were controlled, in order that he might be able to modify these conditions in a favorable manner. The abstraction of the "mind" was so far set aside as to make it certain that this mind could only act through a nervous structure, and that the structure was subject to various influences for good or evil. It became known that a brain cannot arrive at healthy maturity excepting by the assistance of a sufficient supply of healthy blood—that is to say, of good food and pure air. It also became known that the power of a brain will ultimately depend very much upon the way in which it is habitually exercised, and that the practice of schools in this respect left a great deal to be desired. A large amount of costly and pretentious teaching fails dismally for no other reason than because it is not directed to any knowledge of the mode of action of the organ to which the teacher endeavors to appeal; and mental growth in many instances occurs in spite of teaching rather than on account of it. Education, which might once have been defined as an endeavor to expand the intellect by the introduction of mechanically compressed facts, should now be defined as an endeavor favorably to influence a vital process; and, when so regarded, its direction should manifestly fall somewhat into the hands of those by whom the nature of vital processes has been most completely studied. In other words, it becomes neither more nor less than a branch of applied physiology; and physiologists tell us with regard to it that the common processes of teaching are open to the grave objection that they constantly appeal to the lower centres of nervous function, which govern the memory of and the reaction upon sensations, rather than to those higher ones which are the organs of

ratiocination and of volition. Hence a great deal which passes for education is really a degradation of the human brain to efforts below its natural capacities. This applies especially to book-work, in which the memory of sounds in given sequences is often the sole demand of the teacher, and in which the pupil, instead of knowing the meaning of the sounds, often does not know what "meaning" means. As soon as the sequence of the sounds is forgotten nothing remains, and we are then confronted by a question which was once proposed in an inspectorial report: "To what purpose in after-life is a boy taught if the intervention of a school vacation is to be a sufficient excuse for entirely forgetting his instruction?"

In order to avoid such faulty teaching, few agencies are more valuable than what are technically called "object" lessons, in which the faculties of the pupils are exercised about things instead of about words; and the suggestion of Sir John Lubbock would lead to object lessons of a very useful character. To be taught something about gravitation, about atmospheric pressure, about the effects of temperature, and other simple matters of like kind, which would admit of experimental illustration, and which would call upon the learner to make statements in his own words instead of in those of somebody else, would be so many steps toward real mental development. At the end of a vacation, even if the facts of any particular occurrence had become somewhat mixed, the pupils would nevertheless preserve an increased capacity for acquiring new facts, and would probably retain these for a longer period; and such are precisely the changes which it should be the province of education to bring about. We would even go further than Sir John Lubbock, and in elementary schools would give an important place to the art of drawing, which teaches accurate observation of the forms of things. The efforts of a wise teacher should always be guided with reference to the position and surroundings of a child at home, and should seek to supplement the deficiencies of home training and example. Among the wealthier classes the floating information of the family circle often, though by no means always, both excites and gratifies a curiosity about natural phenomena; but among the poor this stimulus to mental growth is almost, if not entirely, wanting. An explanation of the physical causes of common events, such, for instance, as the rising of water in a pump, would usually be a revelation to the pupils of a board school, and would start them upon a track which could hardly fail to render them more skillful workers in any department of industry, and which might even lead some of them to fortune. A wise and benevolent squire set on foot many years ago a school for the children of his laborers, in which drawing and the elements of natural science were carefully taught; and the result was, that the children educated there, instead of remaining at the plough's tail, passed, in an astonishingly large number of cases, into positions of responsibility and profit. On every ground, therefore, we hope that Sir John Lubbock's proposal will at no

distant time be adopted by Parliament; but in the mean while there is a still more important department of teaching which is wholly neglected, and concerning which the deficiencies of home instruction are at least equally manifest. We refer to a proper knowledge of the influence of conduct upon life. It should be the duty of every schoolmaster to try and make his pupils understand how production—that is to say, industry—leads to wealth; and how destruction—that is to say, idleness—leads to poverty. The reason why confidence in others is necessary to all enterprise, and the reason why honesty, in the largest sense of the word, is the only root of confidence, should in like manner be enforced by precept and illustrated by example; and such teaching, if it could only be made general, would do more to heal the breach between capital and labor than all the panaceas of all the politicians who have ever sought to figure as the "friends of the working-man."—*London Times.*

We print with pleasure on another page a remarkable article from the *Times* of Monday. In itself the article may present nothing remarkable to the readers of *Nature*, but, as the deliberate utterance of the leading organ of opinion in this country, it marks a distinct stage of progress toward a more enlightened conception of what constitutes education. We hope that it is significant of the near approach of a radical change of the conception in this country of what subjects should be included in elementary education. We need not be surprised at the fate of Sir John Lubbock's bill for the introduction of elementary science into schools, when such erroneous conceptions of what science is apparently exist in the mind of the Minister of Education in the House of Commons, Lord George Hamilton. The Vice-President of the Council has much to learn, when his idea of the Royal Society, one of the most venerable institutions in the country, is that of a kind of select Polytechnic, where "lectures" are delivered on "biology, chemistry, natural history, mechanics, astronomy, mathematics, and botany." But he is new to his work, and we must hope that the debate of Thursday last may lead him to obtain a more accurate conception of what is meant by elementary science.

Dr. Lyon Playfair, we believe, pointed out what is one of the great hinderances to the introduction of science into elementary schools; the mere name, "science," frightens ministers, inspectors, school boards, and teachers; perhaps if the simpler phrase, "elementary knowledge," were used, the simple-minded individuals in whose hands is the training of our future citizens might find that they themselves had been compelled to become acquainted with it to their cost after they left school, and that it would have been much better for them had they had some little training in it before entering into the thick of the fight.

The most notable feature in the *Times* article, as well as in Thurs-

day's debate, is the fact that it has at last dawned upon the leaders of opinion and the makers of our laws that "education" and "instruction" are different things, and that a man may learn a great many "facts" at school, and have his education to begin when he leaves it. It is lamentable that we have to be continually reminded that we are the only one of the great European countries where this distinction is not recognized and practically carried out in education. Our whole system of education, hitherto, has been a mere cramming of the children's memories with words, words, words, to the weariness of children and teachers, and with results unsatisfactory to all concerned. As the *Times* puts it, "To be taught something about gravitation, about atmospheric pressure, about the effects of temperature, and other simple matters of like kind, which would admit of experimental illustration, and which would call upon the learner to make statements in his own words instead of in those of somebody else, would be so many steps toward real mental development." Sir John Lubbock gave a most conclusive refutation of the idea that the teaching of science must be attended with hitherto unexperienced difficulties, and at the same time proved what a relief science-teaching would be to the ordinary dull routine of instruction, when he told the House that in the Scotch schools the authorities began to take alarm because science-teaching was found so comparatively easy and pleasant by the children. As to the argument that children who have been taught to know something about the object and forces with which they come every day into contact contract a distaste for manual labor, we should have thought it had been long ago played out; it has almost as much force as the story told by another speaker of the boy who had been impudent to his master because the latter could not read his newspaper.

It is unnecessary for us to go again into the merits of the question which has been so often and so thoroughly discussed in these pages, especially as the *Times* has put it quite as forcibly as there is occasion for doing at present. It certainly seems sad, nationally suicidal, indeed, that a few more millions of those who will have the destinies of this country in their hands are likely to be launched into active life, with all their education to acquire, ere legislation steps in to give us the advantages which nearly every other civilized nation gives to its children. Every day we hear of the ignorance of the working-classes, every other month "congresses" are held to devise means to remedy the consequences of this ignorance—ignorance of the laws of health, ignorance of household economy, ignorance of the implements and objects of labor, ignorance of the laws of labor and production, ignorance of the nature of the commonest objects with which they come into contact every day, ignorance of almost everything which it would be useful and nationally beneficial for them to know—an ignorance, alas! more or less shared by the "curled darlings" of the nation. Yet while every day's paper shows how keen is the industrial competition with other

nations, and how in one department after another we are being outstripped by the results of better—i. e., more scientific—knowledge, the poor pittance of "elementary knowledge" asked for in Sir John Lubbock's bill is refused by a minister whose own "education" leaves much to be desired. This state of things cannot long continue, and with such advocates for the children as the *Times* and Mr. Forster, we may hope that next time Sir John Lubbock brings forward his bill it will meet with a happier fate.—*Nature.*

MONERA, AND THE PROBLEM OF LIFE.

By EDMUND MONTGOMERY, M. D.

II.—THE PHYSICAL PHASE OF THE PROBLEM.

LET us suppose that we have before us a living spherule of the uniform viscid material of so-called protoplasm. It is seen slowly to push forth, at some part of its circumference, a conical process; and, after a while, it is seen still more slowly to retract the same. We are here brought face to face with the initial and fundamental manifestation of one of the chief properties of life. For, what we are observing is living motion, incipient motility. How is it accomplished? What changes in the protoplasm have given rise to this duplex movement, first of protrusion, and then of recoil, on the part of a peculiar portion of the living material?

When the phenomenon is closely watched in different kinds of monera, it becomes evident that the conical projections are formed by a portion of the protoplasm, in which the bonds of cohesion are in some way being loosened; for the matter flows out into space with a certain pushing force—it liquefies and expands. This view is quickly corroborated by the unmistakable recontraction and resolidification of the material forming the projections, when retrogression is taking place. It is plain, then, that alternate expansion and contraction are the visible elements of motility.

Strange to say, biologists have as yet only realized the importance of the latter, less fundamental part of this twofold process. They have been so struck with the peculiar contractile power, with the seemingly sensitive shrinking exhibited by the living substance, that they have deemed it the most salient and characteristic manifestation of life. To convey this notion, they generally give to the protoplasm the name of contractile substance.

Now, "contractility" may be a very expressive term for the property by which the protoplasm is enabled to accomplish the second part, the retrograde half of motility; but, even thus restricted, it in-

cludes too much vitalism to suit our present purpose, which is to link the organic to the inorganic world.

We, therefore, cannot allow our scientific inquisitiveness to be arrested by the interposition of a mere name, or *qualitas occulta*. We do not wish to make known to others that contraction actually occurs in the living substance, for that is notorious. We wish to ascertain for ourselves how this contraction is effected—whether it is the work of entirely new forces exclusively appertaining to life, or whether it is the mechanical expression of molecular forces, with which we are already familiar in the domain of inorganic activities. Is it a specifically vital force which executes the contraction of motility? Or is it a molecular activity of a known kind which gives rise to vital motion?

This simple question may appear to some very unexciting; yet, upon its answer turns, nevertheless, the entire problem of life; for it is just at this point that the doom of vitalism has to be sealed. Vitalism or evolution: these two conceptions of Nature are incompatible. Vitalism means essentially the era of metaphysical agencies, the sway of extraneous powers coercing a resisting world of stubborn matter. Evolution means the era of inherent efficiency, the interaction of intrinsic powers ever elevating the constant realm of transient existences. It is of great importance, then, not to be deceived with regard to the exact manner in which this decisive vital act, the contraction of motility, is at all times being performed in Nature.

Fortunately, our monera give us plain information upon this point. It can be proved that it is *chemical decomposition* by which the liquefied and expanded material of the conical projection is caused to assume its former condition and place in space. The living substance contracts because it suffers decomposition, as can be directly witnessed. On the strength of this observation it would be quite legitimate to infer that it must have been *chemical composition* which also caused the reverse activity—which made a portion of the protoplasm start out from its globular limitation, and form a projection measuring in length in some cases more than three times the diameter of the main body. But we are not reduced to mere inference in this instance, so important to the understanding of vitality. By means of various accompanying appearances we can visibly ascertain that it is really a process of chemical composition which underlies the liquefaction and expansion of motility. This leading property of vitality is brought into actual play by the expansion of a certain substance in course of composition, and by the contraction of the same substance in course of decomposition, expansion and contraction being merely the physical concomitants of a definite chemical occurrence. This is shown on the one hand by the products of decomposition being separated and eliminated under our view, and on the other hand by the combining substances being brought together, and effecting their union during inspection. We have no occasion, then, to appeal to the intervention of any specific force in

order to understand motility; that is, to understand it in the same manner as we understand other natural processes not belonging to vitality. We have here evidently only a display of specific chemistry. But, then, chemistry is specific all through down to H_2O, CO_2, and NH_3, and who knows how much further?

Expansion and contraction are, as is well known, no uncommon physical concomitants of mere chemical activity, even without addition or subtraction of masses; and it is of fundamental importance clearly to comprehend that vital expansion and contraction are of the same chemical kind, being due to the intrinsic nature of the compound, not to the mere addition or subtraction of mass.

A part of the protoplasm of a moner expands. Chemical composition of a specific kind has taken place, and now it is the physical property of this peculiar compound to occupy more space than before; then the same part of the moner contracts in consequence of chemical decomposition. It is the physical property of the less complicated organic molecule to occupy so much less space. The mass of the added or separated material fills but a very small part of the entire space of expansion or contraction. The expansion as well as the contraction forms part of the specific nature of those different kinds of protoplasm. The organic substance of the moner, plus the separating molecule, is the expanded material. The organic substance of the moner, minus the separating molecule, is the contracted material. The activities of expansion and contraction are merely the physical expression of the gradual process of composition or decomposition occurring within the living substance; they are marks of the shifting of the special relation existing between the protoplasm and its medium during the transitional stages from one state of equilibrium to another.

The great truth which I wish to make quite evident is, that the specific nature of the acting substance constitutes the real power in motility, and not, as is usually believed, the addition of something from outside.

Vital processes will never become intelligible until it is clearly perceived that all vital efficacy resides in the living substance itself, forms an integral part of its specific nature. Many serious misconceptions are afloat with regard to the source of vital power. Science has as yet scarcely penetrated into the outermost precincts of the laboratory of life. The so-called vital dynamics of the present day are beggarly conceptions when measured against the actual wealth of vital manifestations. All we know is, that if so much pressure, so much heat, etc., will effect a new molecular equilibrium in a certain substance, that substance will return to the medium what it has received from it in reassuming its former state.

Will any one pretend to compute the value of the influences which the living substance in the course of ages has absorbed from its medium, in order to become what it at present is? Yet it is these assimi-

lated, equilibrated influences which constitute its real wealth, its source of power, its store of potential energy, whence all its performances emanate.

In the execution of vital motion matter is to some extent "consumed." During expansion it is consumed—taken up by the expanding substance at the cost of the medium. During contraction it is consumed—taken up by the medium at the cost of the contracting substance.

Now, in conformity with the prevailing one-sided view of motility, which attributes the entire phenomenon to so-called contractility, it is generally supposed that the force displayed during living motion is derived exclusively from the consumption of matter on the part of the medium; and it is also generally supposed that this consumption consists in a process of oxidation. Oxidation, it is said, generates a certain amount of heat; this heat is the real motor power in the case.

It does not much affect the bearings of this view whether the oxidizing material be derived, as some maintain, from the contracting substance itself, or whether, as others think, it be derived from food-ingredients. The combustion of matter, with accompanying evolution of heat, is deemed to be the true source of power; and the contracting substance—the muscular fibres in higher animals—are stated to be playing merely the part of machinery.

Thus viewed, the problem of life may be considered altogether hopeless. The organism then represents nothing but a force-directing engine, in which the combustion of compounds previously put together in vegetables constitutes the actual driving force. Vital manifestations, accordingly, can be only due to the action of the force liberated from vegetable compounds and applied to the organic machinery. Poor Science, of all-powerful vitality, thou art very young yet, and amazingly unconscious withal!

The moving substance, the protoplasm, plays just so much or just so little the part of machinery as the steam does in the steam-engine. The substance H_2O in a calorific medium from about 32° to 212° Fahr., under ordinary atmospheric pressure, occupies a certain space. In a calorific medium above 212°, under the same pressure, it occupies an enormously larger space. This specific property of filling such different spaces, under these different thermal conditions, is the very source of its power—of that motor power which sets the engine going. Whoever wishes to become fully convinced of the fact that it is not the heat of combustion, but the specific expansibility and contractility of H_2O, by which the engine is driven, may just throw, instead of so much H_2O, a proportionate weight of Au into the boiler.

If this remark should happen to appear far too commonplace for the purposes of scientific illustration, I can merely state in defense of it that, perhaps, in pondering over its meaning, the reader will find himself initiated into a deeper view of force than is usually accepted.

It is for the sake of a somewhat commensurate appreciation of vitality, of high-wrought molecular organization, that it is necessary, again and again, to point out the might of potentiality intrinsic to matter, the vast and specific stores of force locked up in the peculiar molecular entanglements which constitute our different substances. All forms of matter are essentially magazines of equilibrated energies: inert against such other energies as have no power to disturb their equilibrium, but seething with incalculable commotion against such other energies as have power to disturb their equilibrium.

What H_2O is to the steam-engine, the moving substance, the protoplasm, is to the living engine. Machinery is fastened on to both these motor powers exactly in the same manner. The expansion and contraction of H_2O give motion to the prearranged and molecularly unyielding levers of the steam-engine. The expansion and contraction of the protoplasm give motion to the prearranged and molecularly unyielding levers of the animal engine. We see the correspondence between an engine and a higher organism is even more complete than is generally conceived by philosophers of the purely mechanical school.

Only, the specific power of the slightly complicated molecule H_2O cannot possibly afford any standard for the estimation of the specific power of the immensely more complicated molecule constituting protoplasm. Protoplasm differs from water in proportion to its synthetical wealth. Whatever synthetical wealth may be the symbol of, in its gradations is to be sought the source of all difference in Nature. This is the gist of what chemistry teaches: the work of Nature consists in molecular synthesis. It has required the ceaseless toil of endless ages to build up the molecule of living matter. Let us then value it accordingly, and nevermore view it under the degrading aspect of stolid machinery.

Motility, then, consists in the alternate expansion and contraction of protoplasm, which expansion and contraction are incited by a process of chemical composition and decomposition occurring within the protoplasm. The property of occupying so much more or so much less space, under these different conditions, belongs entirely to the respective organic substances, which alternately fill the larger and the smaller space. The forces which are brought into activity during the process are forces of a known kind, but essentially inherent in the living substance. They are stimulated, not transferred. They are a display of intrinsic power, not an application of extrinsic power. They are not the heat of combustion pushing together or dragging asunder the molecules of the organic substance; they are part of the expression, i. e., of the influence on the medium, of those most specific chemical affinities which synthetical elaboration has ingrained into the constitution of the protoplasm.

If, in contemplating this truth, so positively disclosed by the study of living matter, it should become evident that the display of all other

force is exactly of the same stimulated and not transferred nature, then, surely, a great advantage will have been thus gained toward a correct understanding of natural phenomena and their relation to each other.

It would then be clearly perceived that Nature does not consist of so many particles of inert matter, held together or pushed about by a set of mysterious agents ; but that it rather consists in the disturbance, the overthrow, and the new formation, of equilibrated states of energies.

I have found myself reluctantly compelled to advance this general statement, in order to fulfill the obligations undertaken in this section. For, how am I to establish the gradual, unbroken development of the organic world from inorganic beginnings, when already in the domain of inorganic activity there are believed to exist so many different modes of force, so many kinds of self-sustained and transferable agents? It is true, the so-called forces, the specific motive activities, by diving into certain substances, are said to be in some unknown way "transformed" or "converted" into each other : so much friction into so much heat, or so much electricity. In this conception the identity of a supposed agent or force is evidently sustained in thought. Struck by the definite proportionality found to obtain between the changes occurring simultaneously in the substratum from which the force is thought to have been transferred, and the substratum to which it is thought to have been transferred, the mind is induced by means of a fictitious entity substantially to connect the changes as such, losing sight of the true substances, of which the changes are in reality mere affections. However much the notion may be formally repudiated, the forces are nevertheless in science still conceived as specific entities ; to which the current expressions "correlation of forces, "equivalence of forces," "transmutation of forces," etc., bear sufficient witness.

If friction can become electric force, why cannot heat become vital force? And this is exactly what is generally maintained. If it be the rubbing that is or makes the electricity in the sealing-wax, then, surely, it must be the heat that is or makes the vitality in the hen's-egg. This also, but somewhat more reservedly, is at times advanced. So much mechanical force converted into so much electric force, in the former instance, whereby—as easily perceived—the preëstablished specific molecular constitution of the sealing-wax is counted for nothing : so much heat converted into so much vital force, in the latter instance, whereby the preëstablished most specific molecular affinities within the egg-substance are counted for nothing. Is not even the proportionality between the changes entirely limited and quantitatively determined by the nature and state of the manifesting substances?

Whether the forces be conceived as specific entities, as definite modes of motion, or as different affections of matter, the idea of their equivalence and convertibility is just as unwarranted, though not so palpably incongruous, as the idea of the equivalence and convertibility of air-

vibrations and sound-perception, of ether-vibrations and light-perception. A certain, even quantitatively definite relation obtains between the intensity of stimulation and the stimulated effect, but that relation is neither one of equivalence nor of convertibility. This fact is universal in Nature, but becomes the more obvious the less the mutually affecting substances resemble each other. It is just as impossible that one kind of force can be converted into another kind of force, as it is impossible for any kind of force to originate out of nothing, or to exist without substratum.

A "force-directing" machine or apparatus corresponds to a well-known intelligible fact. A "force-transforming" machine or apparatus corresponds to something altogether unintelligible. If substances had really any such transforming effect on forces, even then they would themselves constitute specifically intervening powers. But this also is hyperbolical, for it does not adequately express the part which substances actually play in the manifestation of forces.

The now so famous notion of the equivalence and convertibility of forces indicates certainly a desirable attempt to bring under the grasp of Science the subtile balance of energies constituting our phenomenal world, but it partakes still too much of the old metaphysical weakness, under which we are wont to seize the shadow and lose the substance. By admitting molecular affections into the vicious circle of mechanical equivalence, it has, however, imported into it an insuppressibly qualitative element, that sooner or later, by its intense expansiveness, will break the narrowing spell, and open to scientific knowledge new fields of unexpected wealth.

The whole mechanical view of Nature rests chiefly on the supposition that effects are equal to their causes, that they are indeed the causes themselves, metamorphosed in appearance. This notion is radically erroneous, and can never lead to an understanding of reality. *Causa non æquat effectum.* In Nature there exists nothing corresponding to the so-called efficient causes of science, whether single or plural. The scientific conception of cause is a dynamical fiction, made to suit a realm of phantasmal inertia, in which molecularly imperturbable masses pursue forever an unopposed course in a resistless medium. How can we gain an insight into reality by always mathematizing it away?

In Nature all manifestations are the work of opposition and perturbation; agitation of preëxisting states, and subversion of the same. It is in this intrinsic potentiality and mutual affectibility of so-called masses that Nature has its being, its subsistence, and its perfectibility. The substrata of reality are not merely ponderable or imponderable vehicles of locomotion; but concentrations of actual and potential energies, thrilling through and through with consonant sensitiveness, reverberating with an accent of their own every commotion from the centre of the skies to the centre of the earth.

The entire result of development is preserved in the synthetical intricacies of matter and ether, the sensible and the supersensible substratum. All developmental achievement is embodied in what we chemically call complexity of composition. The more complex a substance, the greater its intrinsic value, the more specific its inherent power, and the less congruous in consequence its response to outside influences.

We cannot make any considerable progress in the philosophy of reality, of which the understanding of our own life is the consummation, before we have first formally reënthroned into their actual seat of power the sovereign energies, so strangely slighted during the long reign of visionary potentates—the eras of anthropomorphism and metaphysics.

Now that we are avowedly appealing to Nature for knowledge, it behooves us to become natural in our mode of thinking. To fix our attention merely on changes and their relation to each other is to grasp at the shadow of reality. That which changes is in every respect the substance, the potentiality and actuality in the case; and it is essentially its specific molecular constitution which determines the nature of the change qualitatively and quantitatively. The scientifically ascertained, most specific behavior shown by the various substances, with regard to their manifestation of different modes of force, or even of one and the same mode of force, is in itself abundant proof that that which we call forces are merely specific modes of *reaction* on the part of the various substances.

This somewhat lengthy but indispensable discussion on the nature and seat of force will save us the far greater labor of attempting to account for life by computing the foot-pounds of mechanical energy of which it is supposed to be the transformation; or of seeking a standard for the valuation of brain-power, or any other vital activity, by accurately determining the units of heat obtainable from the substances which exhibit these activities.

"But," it will be asked, "if combustion is in no way essential to the manifestation and production of motility, what part is actually played by the oxygen, which is known to permeate all protoplasm, and which is inhaled in such vast quantities by higher organisms?"

Oxygen is the mighty scavenger in the vital economy, the general purifier and clearer. Everywhere among the crevices and interstices of the vital *nexus* it lies in wait, seizing upon all stray stuff—waste products of function and unassimilable matter of all kinds—and converting the same forthwith into harmless and eliminable compounds. Besides, the heat evolved during this entirely depurative process helps essentially to compose the calorific medium of the organism. But oxidation is in no manner directly conducive to vitality. Within the organism combustion merely hides away death; does not kindle the flame of life; belongs to the domain of destruction, not to that of construction.

Having thus to some extent prepared the way for a more strictly chemical and physical appreciation of vital phenomena, we will proceed, in the next paper, to inquire by what agencies the chemical composition and decomposition of the living substance are effected.

[*To be continued.*]

THE ASTRONOMICAL HISTORY OF WORLDS.

By Professor DANIEL VAUGHAN.

THE information which geologists derive from the evidences of organic remains does not wholly satisfy the keen appetite of educated minds for a knowledge of the mysteries of Nature and the revolutions of past times. The relics disentombed from our globe give no clew to its origin; and they throw but little light on the great physical events which transpired before life appeared on its surface. There are, however, reasonable hopes that the records which are wanting on this earth may be supplied from the heavens; and that some general cause, to which the numerous orbs of celestial space are indebted for their existence, may be revealed from the peculiar character of their movements, or from some of the mysterious phenomena which they occasionally exhibit. In associating his researches with those of the geologist, and in taking cognizance of the great events in the course of time, the astronomer may enhance the value of the inquiries which more commonly fall to his lot. A knowledge of the condition of the earth in past ages is calculated to give much insight into the state of similar orbs in remote space; and opinions of the habitability of other planets must be more valuable in proportion as geology and terrestrial physics show more definitely how our globe acquired and how long it can retain the conditions necessary for the maintenance of life.

The tendency to widen the range of its inquiries and to speculate on the origin of the celestial bodies cannot be considered as a new feature of astronomy. The sudden appearance of the new stars, in 1572 and 1604, led Tycho Brahe and Kepler to the belief that the cosmical vapor or exceedingly rarefied matter of space was occasionally condensed to form great stellar orbs. These crude notions of the quick growth and ephemeral life of great suns were gradually replaced by views less repugnant to reason and experience. In the succeeding age the faintly luminous spots which the telescope revealed in the heavens were regarded as primitive chaotic matter exceedingly rarefied by intense heat, and they were supposed to be undergoing a slow cooling and a gradual condensation which would ultimately convert them into suns or into planetary systems. This opinion, however, though

held by many astronomers, was controverted by others who maintained that the light, supposed to come from primitive fire-mist or nebulous matter, was in reality emitted by extensive sidereal groups, or vast universes too distant to show their individual stars. But, after some time, the round and the oval forms of many of these faint objects were looked upon as marks of a concentration around a centre, and the rare matter seemed to be emerging from its original chaotic state. It was thus that Kant, guided chiefly by the observations of Maupertuis, obtained a basis for his nebular hypothesis, which he published in 1755, and which, in essential features, differs little from that which has been held during the present century. Yet the subject excited little attention until many years afterward, when Sir William Herschel made his extensive and careful observations on planetary nebulæ, and pronounced them incipient solar systems, while he looked on irregular nebulosity as indicative of the presence of distant collections of stars.

As the doctrine founded on these observations was generalized by Laplace and supported by him with additional evidence, it obtained for a while much currency in astronomical circles; but it was seriously shaken in 1845, when many of the supposed embryonic systems of Herschel were resolved into stars by the powerful telescope of Lord Rosse. Yet, after a decline for a few years, the nebular hypothesis was revived on this side of the Atlantic by the announcement of Kirkwood's analogy; and some time afterward it obtained more decided support from the authority of Kirchhoff, as, on the discovery of spectrum analysis, it seemed to furnish a good explanation of solar phenomena. When Huggins obtained positive proof of the gaseous constitution of many of the irresolvable nebulæ, the tide of scientific opinion set more strongly in favor of the views of Herschel and Laplace; but it was soon checked when it was found that all the true nebulous objects had a uniformity of composition, and consisted entirely of hydrogen, nitrogen, and an unknown gas. It seems impossible that the vast diversity of material objects in future families of worlds could be afforded by the agency of three elements, one of which is noted for its reluctance to take part in chemical combinations. In addition to this difficulty, the periodical and the permanent changes, detected in certain nebulous objects by Hind and Holden, differ widely from a slow transition into a planetary system; and they are fatal to the idea that these cosmical clouds were in past ages impassive to physical influences and departed little from their primitive condition. But facts still more difficult of explanation, in regard to these celestial objects, have been made known by the recent observations on Nova Cygni; and the apparent metamorphosis which was witnessed, of a temporary star into a nebula, was so little expected that theory seems much at fault; and it is evident that many of the views on this obscure department of astronomy must be either considerably modified or entirely abandoned.

According to the crude opinions prevailing during the infancy of

modern science, matter and motion were all required for calling a world into existence; but it was soon found that, unless, in the beginning, the materials which formed the solar system moved with a certain order and regularity, they could never have risen from the chaotic to the cosmical condition. As all the planets move around the sun in the same direction, Laplace was led to believe that in remote times all must have been connected together; and such a primitive connection might be afforded if the sun and his attendants were originally a vast fire-mist, their matter being so much attenuated by heat that it extended far beyond its boundaries of the solar domain. He supposed that such an immense rarefied mass, on being set in motion by some cause which he does not specify, would ultimately be compelled by its own friction and by gravity to rotate with a uniform angular velocity in all its parts and around a common centre. In accordance with the principles of physical astronomy, he concluded that this rotation would become rapid as the immense solar nebula cooled and contracted, until at last the centrifugal force became great enough to overpower gravity and to throw off matter from the equator of the whirling mass. Laplace considered that, under the most probable circumstances, the nebulous matter thus thrown off, or abandoned by the shrinking spheroid, would all collect together to form a planet; but that, in some unusual cases, it would assume the expanded figure of a vast solar ring; and that, under certain conditions, it might break up into a number of asteroids. The singular group of bodies revolving between Mars and Jupiter is supposed to have come into existence in consequence of some rare accident, which made the great solar ring a prey to many centres of aggregation, instead of allowing it to coalesce around a single one. In all other cases, the cooling and contraction are said to have been successful in giving birth to a great planet, whenever the centrifugal force became sufficient to separate the equatorial portions of the rotating solar nebula. According to the views of Laplace, Neptune must be regarded as the first-born world of those already known; while Uranus is next in age, and the other planets were launched into being in a succession depending on their distances from the sun; so that Mercury is the youngest member of the solar family. It has been also concluded that from the condition of its birth each planet must have commenced its career as a rotating nebula; and that many of the larger ones, by subsequent cooling and contraction, were at certain periods enabled to throw off their equatorial matter, which in all but two instances was converted into a satellite. Of these minor worlds or moons, Saturn has succeeded in obtaining eight, in addition to the double ring, which in the eyes of Laplace appeared as two embryonic satellites, and which has been so often appealed to for proof of the world-making doctrine under consideration.

Yet, when examined with care and impartiality, the evidence derived from the condition of the Saturnian girdle will be found unfavorable, if

not fatal, to the views which it has been so frequently adduced to sustain. The superficial character of the examination which Laplace has given to this subject is betrayed by two statements which he makes in regard to it in two different parts of his writings. In setting forth the nebular hypothesis in his "Système du Monde," he asserts that the matter separated from a contracting nebula would take and maintain an annular figure, if there were a complete uniformity in its entire circuit and in its rate of cooling; but in the "Mécanique Céleste," in treating on Saturn's rings, he concludes that their preservation would be impossible without some decided irregularities in their structure. It is scarcely necessary to say that the annular appendage could not be of long duration if the conditions necessary for its existence or security in one age were fatal to it at another. On examining the alleged history of its birth, also, we feel at a loss for some cause of intermission in the work of detaching matter from the cooling nebula. It is difficult to imagine why, after the outer ring was completed, the separation of matter from Saturn, after a long continuance, should have ceased for a while; and why, after the completion of the inner ring, the centrifugal force again became weak, and that it has declined steadily until the present time, when, at the planet's equator, it is scarcely one-sixth of the force of gravity. Since the period when Saturn is supposed to have launched forth the zone of matter circulating nearest to him, his movements could be but little retarded by tidal action; and there seems to be no cause which could reduce his angular velocity of rotation during a contraction from the loss of primitive heat.

Kant, who regarded the rings as composed of aëriform matter separated from Saturn, was led to the natural inference that the time in which the planet turns once on his axis must be equal to that which the nearest annular zone requires to make a circuit around him. From such considerations, the eminent *savant* was induced to assign for the rotation of the planet the period of six hours, twenty-three minutes, and fifty-three seconds. But this theoretical or predicted length of Saturn's day is only about three-fifths of the actual value which was first revealed by the observations of Sir William Herschel, and lately determined with more precision by Prof. A. Hall. From the difficulties which the facts present in this case, Laplace endeavors to extricate his doctrine of planetary evolution by maintaining that it requires only that Saturn's day should be shorter than the period of revolution due to the inner ring, supposed to be one unbroken solid mass. But the basis on which this conclusion is founded has been exploded by modern researches, which show the impossibility of the existence of such vast solid annular structures; and Prof. Kirkwood, though long a supporter of the views of the great French astronomer, has lately pronounced the evidence obtained from the Saturnian system and from the inner moon of Mars as adverse to the nebular hypothesis.

While all scientific researches are exposed to uncertainty in propor-

tion as they aim to penetrate very far into space and time, the ordinary means for avoiding error are wanting, and mathematical investigation is unavailable, in dealing with the supposed primitive fire-mist to which the birth of worlds has been ascribed. It would be hazardous to attempt to calculate or to trace the precise effects of gravity, motion, and friction, on matter more than 100,000,000 times more rarefied than the air we breathe, and diffused over a spheroidal space more than 6,000,000,000 miles in extent. It may seem easy to suppose all its parts rotating with regularity in the same direction around a common axis; but it would be very difficult to determine how many millions of years or centuries must elapse before such a regular rotation of the entire mass would be produced by an impulse at any locality. Inquiries respecting the arrangement of matter in the primitive solar nebula may seem to come within the scope of physical science; yet they have been hitherto unproductive of the evidence expected from them. Reasoning from the principles of hydrostatics, Kant regarded the great density of the planets near the sun and the rarity of Saturn as a proof of their nebulous origin; and he ventured to predict that, on future discoveries, the most remote members of the solar system would be found to resemble comets, in being composed of very light matter and deviating widely from circular paths in their revolutions. Yet time has shown the fallacy of his predictions, and of the proof on which he placed so much reliance. The evidence which late writers have endeavored to deduce from the large size of Jupiter and Saturn is equally weak and unsatisfactory; for the most distant planets are not the largest, and there is no definite law calling for an increased size of worlds in proportion as they are distant from the solar orb. According to the most generally received theory of its variability, the star Algol presents the case of a remote sun with a planet nearly as large as himself, yet confined to so small an orbit that the period of revolution is less than three days. But the defects and the utter inadequacy of the hypothesis are rendered most apparent when it is called on to furnish an account of the origin of binary systems, and to show the cause of the great eccentricities of the ellipses which pairs of distant suns describe around a common centre of gravity.

In modern times the doctrine of the nebular origin of worlds has been much modified by new speculations and inquiries; and it has been extended far beyond the state in which it was left by Herschel and Laplace. More than twenty years ago Helmholtz advanced the hypothesis that the sun's heat and light are produced by the contraction of his mass; and that, in concentrating from primitive nebulous diffusion and shrinking to its present dimensions, the solar orb has derived from the same cause the calorific energy which enlivened the ancient world. When the views of Mayer, who regarded falling meteors as the solar fuel, were exploded, chiefly through the discoveries by the spectroscope, the contraction theory of Helmholtz gained many votaries; and it be-

came more attractive as it held out the hopes of giving a means of definitely measuring vast periods of time. It was calculated that the concentration from a widely-diffused nebula to its present size would produce as much heat as the sun would lose in 20,000,000 years, according to the present rate of radiation. This period was accordingly fixed as the age of the sun and the duration of solar light. Another step was soon taken in this direction by fixing a limit to the age of worlds. It was concluded, with much confidence, that less than 20,000,000 years have elapsed since the earth became a planet, and that previously it must have formed a part of the solar atmosphere. In Prof. Tait's "Recent Advances in Science," the estimate obtained in this way for the age of our globe is placed between 15,000,000 and 20,000,000 years; and geologists are given to understand that they must recognize the infallibility of mathematical authority and abstain from their usual extravagance in making exceedingly large drafts on the limited fund of time.

But the conditions on which this surrender of geological belief has been demanded are far more liberal than any which the eminent mathematician is legitimately authorized to offer. The estimate on which he relies has been made for an homogeneous nebula supposed to be equally dense at its borders and in its central regions, whereas there must be a preponderating density near the centre, according to the necessary inferences from the doctrines of Laplace. This early central condensation must be adopted to account for the great mass of the sun compared with that of the planets. In an able investigation on the subject, in this point of view, published in *Silliman's Journal* in 1864, Prof. Trowbridge concludes that, even in the earliest stage of planetary development, there must have been a very great concentration of matter around the central nucleus of our solar nebula. If we adopt the law which he deduces for the rapid increase of density toward the centre, it may be found that the amount of heat due to contraction since the supposed birth of our world would not be enough to compensate for the calorific waste which the sun sustains in 1,000,000 years.

To obtain information of the age of the earth's crust from the increase of subterranean temperature with the depth, according to the method devised by Fourier, is an object to which much labor has been devoted, and from which valuable fruits may be expected. On this principle, the time since the permanent solidification of the surface of our globe has been estimated by Sir William Thomson at about 100,000,000 years. But this estimate, which is obtained by taking 7,000° Fahr. as the highest limit of internal temperature, will appear too low when we consider the vast amount of heat arising from the primitive concentration of terrestrial materials, and the obstacles which central density or igneous fusion may present to its escape. Instead, however, of controverting the peculiar views of the eminent scientist on physical geology, I will only trace the consequences to which they lead. He maintains

that, in a molten globe, the rocks which became solid should sink into the fiery menstruum; that permanent solidification must have accordingly commenced at the centre and ended at the surface, leaving some internal lakes or pockets of lava to keep up volcanic action. Now, such reservoirs of molten rock should have a small size in order to receive a roof in opposition to the laws of hydrostatics; and, if much of the original fluidity of their contents is still preserved, notwithstanding their immense losses of heat, especially during volcanic eruptions, we are compelled to make a very high estimate of the time required for the solidification of a fused globe 8,000 miles in diameter; and we must conclude that the time since the earth was covered by a permanent crust is but a very small part of that which has elapsed since terrestrial matter began its career in a gaseous or in a molten condition.

Though deprived by recent investigations of much of the support first claimed for it by Hopkins, the doctrine of the almost total solidity of the internal earth is still held by many; and, in the hands of Thomson and Tait, it is made to contribute to the evidences of the youth of our planet. They consider that, with such a solid and inflexible constitution, the terrestrial structure must have retained almost immutably, to the present day, the exact shape impressed on it in the beginning. As the figure which it now bears differs little from that of equilibrium, and as the polar compression is nearly the same as that which the present diurnal movement would occasion in a molten world, it has been concluded that, during geological history, the length of our day has changed little, though it would be increased by tidal friction one per cent. in the course of 20,000,000 years. From such considerations, the period since our earth assumed its terraqueous character has been estimated at not more than 10,000,000 years. Yet, in the vague use of this round number for marking the career of our globe, there is shown a wish rather to fix a limit to geological time than to adhere to strict mathematical precision. So little does the earth deviate from a figure of equilibrium, and so imperfect are the means for ascertaining the exact amount of the deviation, that it would be hazardous to say whether the age obtained by this course for the terrestrial crust is nearer to 1,000,000 or to 10,000,000 years.

Far more satisfactory would be the issue in dealing with a case like the hypothetical one which Prof. Tait introduces for illustration. Alluding to the ancient world he says: "Suppose, for instance, that it had not consolidated at less than 1,000,000,000 years ago. Calculation shows that at that time, at a moderate computation, it must have been rotating twice as fast as it now rotates; that is to say, the day must have been twelve hours instead of twenty-four. Now, if that had been the case, and the earth still fluid throughout or even pasty, the double rate of rotation would have produced four times as great centrifugal force; and the flattening of the earth's poles and the bulging out of the equator would have been much greater than we find them to be."

There is, indeed, no doubt that, under such circumstances, the flattening would be about four times as great as it is now, so that the difference between the equatorial and polar diameters would be about a hundred miles; and then the age of our world might be found as accurately as its distance from the sun. Now, the neighboring zone of the solar system presents an actual case very similar to the extreme one under consideration. The difference between the equatorial and polar diameters of Mars is at least three times as great as that which could be expected from his present rotation if he were in a fluid condition. On taking even the lowest values which observers give for his compression, it must be concluded that, since changing his primitive fluid state and becoming solid and inflexible, the planet must have lost about forty per cent. of its diurnal motion. It evidently follows, according to Prof. Tait's rule, that about 800,000,000 years elapsed since the solidification took place, supposing the length of the day of Mars increased at the same rate as that of our globe. But the same great number will seem scarcely adequate to express the centuries since the event, when we consider that the rotation of our planetary neighbor is checked, not by strong tidal friction, but by the more feeble impediment from the resisting medium of space.

In two publications, during 1856 and 1858, I discussed the geological consequences of the slow reduction in the earth's diurnal motion; and many reasons led me to the conclusion that the long-continued decline of centrifugal force would make our planet undergo a change of form, by the gradual retirement of water to the poles, and, after long ages, by the upheaval of the bottoms of the polar oceans. I also maintained that such upheavals of circumpolar lands would be prevented by the strength of the crust of a small planet, and that Mars would be able to preserve for an exceedingly long period the form impressed on him in the very early term of his existence. The earth's internal fluidity, which I regarded as playing a very important part in such rare paroxysmal events, has been long a favorite doctrine with geologists, and has been often invoked as a means of accounting for the oft-repeated cases of elevation and submergence in the ancient world. But, on a globe entirely solid and inflexible, there would seem to be no scope or even possibility of the vast changes recorded in geological history; and speculative astronomy, in curtailing the time and restricting the means of great physical revolutions, makes the information from organic remains difficult to be understood and deficient in value. Since the authority of Hopkins gave currency to the doctrine of the internal solidity of our globe, much scientific talent has been expended in attempting to account for the great geological changes; but the causes which have been appealed to would require millions of centuries to produce the results ascribed to them. It seems very difficult to set aside the opinion which has been formed of the high antiquity of the physical world, not only from the marks in the terrestrial crust of repeated ele-

vations and depressions, but also from a knowledge of the insignificant alterations in the outline of continents during the last 3,000 years.

In the imaginary systems of celestial architecture which Aristotle and Ptolemy gave to mankind, there was a very narrow limit assigned to the extent of the heavens; the entire stellar host was supposed to be confined to a very scanty domain, and the human mind was prevented by these erroneous dogmas from rising to a knowledge of the magnitude or the riches of the universe. If science, in former ages, had been crippled by being restricted to too narrow a region of space, it cannot avoid suffering, at the present day, from being subjected to similar restrictions with respect to the range of time which its researches should embrace. On grounds as uncertain as those which sustained many of the exploded doctrines of antiquity, it has been too hastily concluded that the past career of the earth and the duration of solar light must have been comprised within the course of a few millions of years. It is even supposed that, within a like circumscribed period of charge and activity, the myriads of solar systems in the wide domains of space around us came into existence from chaotic fire-mist which filled the entire universe. The transitory character which modern speculation would thus assign to many important cosmical arrangements will appear more surprising if contrasted with the long endurance of others, as revealed by the older and the ripe fruits of physical astronomy. From the planetary theories of Lagrange and Laplace it would appear that the future life of the solar family, if not absolutely eternal, must be many thousand or even a few million times as long as the period into which certain modern scientific writers are endeavoring to squeeze geological history. According to Proctor, 20,000,000,000,000 years must elapse before even Mercury can meet a natural death by incorporating with the sun; and this estimate, which I believe to be somewhat too high, is introduced here to give an idea of the opinions prevailing on the subject in astronomical circles. It may, however, be safely asserted that the future age of the earth cannot be much less than a million times as long as the period during which the sun's contraction could supply heat and light, at the equable rate which the purposes of life require; and there is no reason to admire a course of creation which makes worlds outlive so long their term of utility, and condemns solar systems in coming time to endure an interminable reign of darkness.

In proceeding to trace the course of the great cosmical events throughout the universe, it seems necessary to begin with a careful study of the permanent alteration in the movements of the earth and many of the celestial bodies. During the prevalence of the ancient doctrine of the immutability of the heavens, the occurrence of such unperiodical changes was denied. Even in modern times they were long ignored, as they proceed so slowly that it is only in a few cases that they can be revealed by the most refined methods of theory and observation. During the last century the doctrine of the uniformity

of Nature held such a sway over scientific opinion that even slight accession of foreign matter to the earth by falling meteors would not be admitted. As, even at the present day, the origin of meteoric stones and shooting-stars cannot be said to be entirely free from doubt, I shall not introduce them for evidence in this stage of my inquiry, as items of the greatest certainty must claim the first attention. There is, indeed, no doubt that, if the mass of the sun were increased by falling meteors, his greater attractive power would make the planets describe smaller ellipses and occupy less time in their revolutions. Were the large worlds also to have their attraction increased by similar accessions of meteoric matter, they would reduce the orbits and quicken the speed of their satellites. Analogous results should be indirectly occasioned to both classes of planets by the resistance of the medium supposed to pervade space. But tidal friction is the best known impediment to planetary motion, and the changes which it slowly occasions in the condition and the career of the celestial bodies come more decidedly within the range of the investigations of modern science.

This retarding influence has been studied much in modern times, in so far as it affects the rotation of the earth, and even the movements of the moon. More than a hundred years ago Kant maintained that the tide-wave, in rolling from east to west, would reduce the earth's diurnal motion; but no positive proof of this conclusion could be given for a long time, in consequence of the peculiar difficulties of the inquiry and the imperfect condition of the tidal theory. Laplace, in dealing with the problem, concluded that within the last 2,000 years the length of the day has not been perceptibly affected by the alternate rise and fall of our oceans. But about thirty years ago, when science was enriched by the development of the doctrines respecting the conservation and the transformation of energy, the question of the effects of tidal friction was again opened for discussion, and Mayer was able to reproduce and to maintain on new grounds the almost forgotten doctrine of Kant. The evidence on which Mayer based his convictions was subsequently strengthened by a discovery which Prof. Adams made, of an error in the investigations of Laplace; and soon afterward Delaunay, in taking up the inquiry and repeating the previous operations with great care, found that the earth's diurnal motion is reduced on a scale corresponding to the waste of power involved in tidal movements. Although the amount of energy thus wasted has been estimated as over two thousand times greater than that of the united labor of the entire human population, yet so great is the stock of working force embodied in terrestrial rotation that 20,000,000 years must elapse before the length of our day is increased one per cent. by tidal friction.

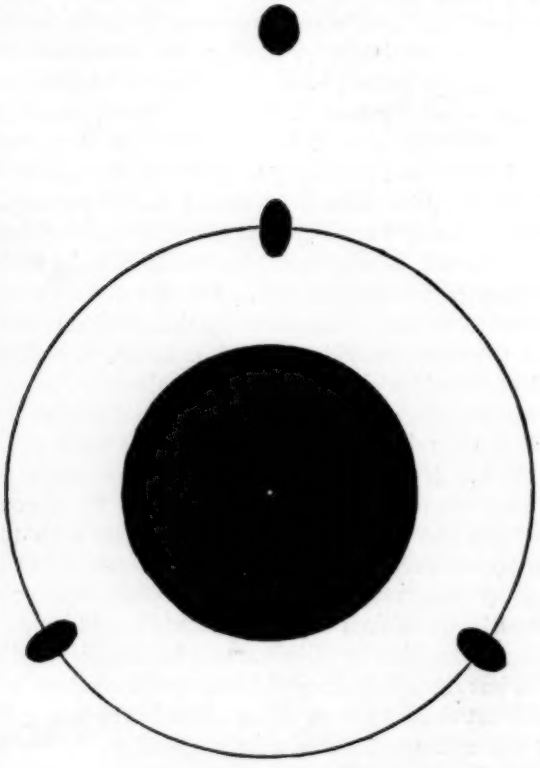
The alteration which the moon occasions in terrestrial gravity is too small to be detected by the most delicate experiment; and it might remain forever unknown if our watery domain were not so sensitive to

extraneous disturbance. A tidal force more than a thousand times greater prevails on the majority of the known secondary planets. If our globe, while keeping its present rotation, could exchange orbits with Jupiter's first satellite, our oceans would feel a periodical disturbance more than 20,000 times as powerful as that which now affects them; and perhaps few mountains would be high enough to escape being covered by the daily swelling of the waters. But by such a violent oceanic movement the earth's rotation should rapidly change until it kept pace with the revolution · and then the destructive tides would come to a close, as our planet, having the same hemisphere ever turned to Jupiter, would ever elongate in the same direction, and our oceans would be elevated in the same localities. Now, all the secondary planets, so far as observation has been able to decide, have their movements so adjusted as to keep the same ever turned to the primary. This arrangement, so necessary for security against excessive tides in a terraqueous satellite, would be the inevitable result of tidal friction during past ages. Even in the absence of a liquid envelope, the same result would be produced by the deformation which a solid satellite would experience from the enormous tidal force, if it turned at such a rate as to present its different sides alternately to the primary.

Yet, notwithstanding this arrangement, a satellite would experience tidal oscillation, though on a lower scale, if its path deviated much from a true circle. If a watery envelope had been given to the moon in the same proportion as it has been to our globe, there would be tides occasioned by the periodical change of distance between the two bodies, the lunar waters pressing during nearly fourteen days to the points nearest and most distant from the earth, and then retiring to other localities. The friction in such tidal movements would have the effect of making the moon describe an ellipse somewhat smaller and nearer to a circle in form, but the alterations which it could produce in the lunar distance could not exceed two or three miles in the course of a million years. Yet the agency of permanent changes, so feeble in the supposed case, may in the vicinity of great central orbs, and in the absence of great periodical disturbances, become potent enough to impress peculiar features on the paths of secondary planets. To the tides which rose on their surfaces in past times, as well as to oscillations in their solid matter, the first and second satellites of Jupiter seem mainly indebted for their peculiarity in revolving in true circles; while in the orbit of the third moon there is a slight and in that of the fourth a considerable deviation from a circular figure.

I shall now proceed to the examination of cases in which the cause under consideration becomes far more potent, and under the required conditions makes its effects recognizable by observation, and admitting of no doubt. The powerful tidal action which a great central orb is capable of exerting in its immediate vicinity would render it impossible for satellites to hold their parts together if revolving close to its

surface. In a somewhat wider zone, the planetary structure could be only preserved under the form of an ellipsoid, which would deviate widely from a sphere, not so much on account of its rotation as from the effects of the unequal attraction which its different parts receive from the primary. The accompanying diagram shows the equilibrium form of a satellite moving in a circle around a large sphere, both bodies



being equally dense and separated by small distances. In a somewhat greater proximity to the primary, the satellite would be reduced to a state of instability; and its matter, if not kept together by a great cohesive power, would scatter into independent orbits, and ultimately form a ring. There are, perhaps, in our solar domain too few cases to show how excessive tidal action can produce its definite results in its various degrees of power. If the nearest satellite of Mars bore to its primary such relations of size and density as subsist between the earth and the moon, it would, no doubt, surpass all known planets in deviating from a true sphere, even though its materials were not of the most yielding character. If similar relations existed between Saturn and his closest secondary, the latter would show a greater deviation than the primary does from a spherical form.

In the limited number of cases which one system is capable of affording, we cannot expect to see the last struggles of a satellite to maintain its planetary structure when moving in a very close proximity to its primary. But the wonderful annular girdle around Saturn shows evidence not only of a great conflict for planetary existence in past times, but even of lesser ones, on an extensive scale, at the present day. From the investigations which I have published on the subject in the *Philosophical Magazine*, it appears that in the zone of the outer ring a satellite as dense as Saturn could not hold its parts together, and that one twice as dense could not move in safety in the central zone of the inner ring. If, in treating on stability in small orbits, I have generally supposed the satellite fluid in my papers on the subject, it was because they were chiefly intended to decide whether or not it was possible for the matter of the rings to unite and form two secondary planets.

The long-cherished idea that the rings are two integral solid masses is now generally abandoned. For such a constitution the nearer ring would require to be composed of materials over 200 times as strong as wrought-iron, in order to escape rupture; but even this condition could not avert destruction from other dangers to which it is exposed. From the estimates and observations of Bond, as well as from the theoretical researches of Pierce and Maxwell, it appears certain that the innumerable parts of Saturn's ring cannot be all connected together, in a rigid or permanent manner, but must move independently around the great planet. But, while affording much valuable negative information on the subject, the investigations of these eminent mathematicians do not show how the floating matter eternally circulating in these extensive zones is kept from concentrating into two satellites by the impulse of gravity. The cause which prevents this aggregation is to be found in the *proximity of Saturn*, whose tidal action either annuls gravity or reduces it so much in two directions as to render a planetary structure unstable; and though an incipient satellite may constantly grow by appropriating the floating matter around it, yet it must fall to pieces before it has attained any considerable magnitude. The state of the rings thus depends not on accidental but on inevitable circumstances; and, with this basis for our inquiries on the subject, we may arrive at very important information in regard to the past and the future condition of worlds.

GENEALOGY.

By JOHN AMPHLETT.

THERE can be no doubt that, as each person now living has had a father and mother, grandfathers and grandmothers, and so on, every one really comes of as old a family as every one else. Moreover, every living eldest son is the heir male of either the senior or a junior

branch, not only of the family of the man who first bore his name, but of progenitors hidden still deeper in the mists of antiquity. We so often hear of families either dying out altogether or ending in females, that we come to think that such a fate is the eventual end of all families; but this is far from being the case. Every man living could, if he only knew where to find the data, count up from son to father, from father to grandfather, from generation to generation, until he came to Adam himself. And this is the great difference between good families and families of all other kinds: the members of a good family can tell who their forefathers were, where they lived, and whom they married; while those who belong to no families in particular are classed in a body as those who don't know their own grandfathers, or who perhaps never had any to know. The goodness of a family depends much more on the number of its known generations than on any other condition. Given two families in which the numbers of recorded generations are equal, doubtless the family whose members have been the more illustrious would be reckoned the better of the two; but a family of only two or three generations, however illustrious their members might have been, would certainly not constitute what is known as a good family. As in the case of many popular ideas, there is some little substratum of reason in this belief. If to be educated and cultivated is an object of ambition, and if there is anything in the doctrine of heredity, it may be supposed that the members of a family who have been of importance enough to leave their names scattered on the bank of the river of time have had a better chance of being polished, and of handing down their good qualities to their posterity, than those who were swept away by the tide without leaving any mark.

It is not much to be wondered at that there is such a general mistiness as to the ancestors of any particular person. I wonder how many readers of this page can tell straight off the Christian names of their two grandmothers—very few, I suspect—and yet these are facts very close at home in any one's genealogy. I am sure no one who has not especially looked up the point could tell the Christian names of his great-grandmothers, though they also stand at the threshold of a pedigree. Unless recorded in the family Bible or otherwise committed to writing, such names soon fade from the memory. People are anxious enough that they themselves shall not be forgotten. Such a feeling is the root of all ambition; and there is a difference in degree only, not in kind, between writing one's name on the page of the history of one's country and carving one's initials on a wooden bench, or scribbling them with pencil on the walls of some famous and frequented house. But people are not so desirous to perpetuate their father's memory, or to hand down to future ages their grandfather's name, and they take no steps to that end; and the consequence is that of the mass of the people below the class immortalized in such books as Burke's "Landed Gentry," but few know whence they come, or anything at all about

their antecedents. And yet among all ranks of people, from the highest to the lowest, there is some curiosity upon the subject, which, though usually languid, is always ready, should circumstances so direct, to burst into a flame.

It is a pity, however, that this flame should be fed with improper fuel to the extent that it is. When a new man rises up above the mean to such a degree that he thinks it necessary to inquire into his ancestry, his first conclusion is that he must necessarily be related to the best-known family of the name he happens to bear. Should that name be Howard, he considers himself related to the house of Norfolk; should his patronymic be Percy, he deems himself sprung from the same ancestry as the Duke of Northumberland; and if his name be Herbert, he claims affinity with the ennobled family of that name. While his ardor is fresh upon him, in his ignorance he probably applies to some professed pedigree-monger, who at once furnishes him with the missing links between himself and the great family he considers himself to belong to, and affixes to the sophisticated article the trade-mark, the coat-of-arms and crest, which belongs to the real thing; thereby confirming the *parvenu* in his ideas, and satisfying him that his views are correct. Of course it may be that the Howard in question is really sprung from the same ancestry as the Duke of Norfolk; and, indeed, the longer back a family can be traced to have existed, the more likely it is that some of its collateral branches will have sunk down to a lower level of society and have lost all knowledge of their origin. In fact, in the neighborhood of the seat of an old family are usually to be found persons bearing the same name, in all ranks of life, from the yeoman to the laborer. Perhaps they are not all related, for before surnames became fixed in the lower ranks of life the name of a leading family might have been assumed by persons whose connection with it was not that of blood, but of servitude or tenancy, or of some similar nature. In the fourteenth and fifteenth centuries a practice existed of alienating coats-of-arms from one person to another by deed, and grants by barons to their tenants of their own bearings more or less modified were not uncommon. If this occurred with matters so important as coats-of-arms were in those times, we may be sure that the same thing went on with regard to surnames; and in the rush to secure a name which must have taken place in the twelfth and thirteenth centuries, and which worked from above downward, the name of a neighboring family which was already provided with that desirable appendage must frequently, either with or without permission, have been assumed or obtained; sometimes, perhaps, without any connection at all with the original owners, but merely because such a name was already in existence.

The earliest documents in which names occur in any plenty, and from which we can judge of their distribution, are parish registers. In these we find that in each parish there is usually a marked preponder-

ance of one name, which is probably peculiar to the parish, or to a group of parishes, of which the one in question forms a component part. We find names localized in groups, each group having a centre of density, thinning off, so to speak, toward the edges, and overlapping the groups of other names. In those times locomotion was difficult, and country-people were content to remain where they were born, and intermarry with their near neighbors; but nowadays people are more gad-about, and we should expect to find that such centres of names were broken up. Let us look at a book which deals with names on a large scale—I mean the new "Doomsday-Book." This is not a very good source for information on the subject, for the area, the county, is too large, and the standard of admission for a name, the ownership of land, too high for our purpose; but it is easily consulted, and can give us some idea of the localization of names. It will be seen that many names are nearly confined to, or greatly preponderate in, certain counties. For instance, Goddard is a south-country name, numerous in Hampshire and Wiltshire, occurring but seldom in the midland counties, and not met with in the north, not one person of that name appearing in the list of landowners for Yorkshire. Charlton occurs plentifully in Northumberland, and seldom in the southern half of England. Booth, Ibbotson, and several other names, have their headquarters in the West Riding of Yorkshire, while even such common names as Taylor, Robinson, and such like, occur much more frequently in some counties than in others. Five Shakespears hold land in Warwickshire, and one in the adjoining county of Worcester, but in no other county does the name appear. If names occur thus in groups in modern times, we can easily understand that they were still more localized three or four hundred years ago; and if they are thus localized in a return of landowners, we should find the localization still more apparent if we were to take into account the whole population of the various neighborhoods.

Of the importance of keeping a record of the genealogy of a family it is needless to speak. It is to appeal to a very low standard of usefulness to point to the numbers of advertisements for next of kin, and notices of unclaimed money. Since the establishment of a national system of registration of births, marriages, and deaths, there is not so much chance of the relationships of families being lost as there was in the days of the more careless registration which preceded its institution. But this only dates from 1837; and, moreover, the all-embracing nature of the system causes so many names to be brought together, that an extended search among them is a long and tiring process. It is a useful auxiliary to private registration, but cannot wholly supersede it. The date and place of either of the three occurrences in the life of a person with which genealogy especially concerns itself being known, it is easy to get an official record of the fact from the registrar-general; but to start with only a name, and to have to look through index after

index to find the date of the birth or death of the particular person in question, is a very different matter.

And no one should say that he is too humble in station to make care about such things necessary. Fortune's wheel has many surprising turns, and sometimes carries those round with it who least expect to be raised from their station underneath it. To those higher in rank also the due recording of such things is equally important, for many facts concerning their families can be jotted down which must be interesting and may be useful to those who come after them, and which their posterity can learn in no other manner. In fact, it seems to me that the higher the state of culture of society becomes, the more care will be demanded in matters which so closely concern the family and the race; the more society will ask what it is and whence it springs, and in an increased degree will it be true that "the glory of children are their fathers."—*Gentleman's Magazine.*

AN INFANT'S PROGRESS IN LANGUAGE.

By FREDERICK POLLOCK.

THE following notes were made in humble following of Mr. Darwin's and M. Taine's example, at first for my own amusement and without any distinct purpose of letting them go further. I found, however, that they grew under my hands, and that the editor of *Mind* thought further contributions on the subject of children's mental growth would be desirable. Here I have kept in the main to the one point of language, and, though I have probably omitted much, I think I have set down nothing as fact which has not been actually and distinctly observed. Exact dates I have not attempted to give, conceiving that they would be of no use unless for the comparison of a very large number of observations. Children differ so much in forwardness that the time of particular acquisitions seems of little importance as compared with their order. Though I have no pretensions to skill in phonetics, I thought it at least desirable to use some consistent notation for the sounds actually produced. For this purpose I have taken the Indian Government system, with a few additional signs which will speak for themselves. I may explain that in this notation, while *á*, *í*, are the long Continental *a* and *i*, unaccented *a* is not the short Continental *a*, but the obscure or neutral vowel (*Urvocal*) heard in English "at," "that," "but," when not emphatic; when strongly given, it becomes the full sound of *u* in emphasized "but." Thus the Punjaub, Lucknow, Kurrachee, of popular use, become in the official spelling *Panjáb*, *Lakhnau*, *Karachi*. "Governor and Company" would be written *Gavarnar*

and Kampani. The vowel-sound in "bank," which does not occur in Indian languages, could be expressed only by some special symbol. I use *á* for the broad sound of *a* in "fall." Words in italics are in the Indian Government spelling. Words between inverted commas are in ordinary English spelling.

Age, twelve months. *M-m* often repeated; *Bá bá* repeated an indefinite number of times.

M-m generally indicated a want of something. *Bá bá* was: 1. A sort of general demonstrative, standing for the child herself, other people, or the cat (I do not think she applied it to inanimate objects); 2. An interjection expressing satisfaction. Both sounds, however, seemed often to be made without distinct intention, as mere exercise of the vocal organs.

Thirteen months. *Dá dá; Wa wa* (water, drink); *Wah wah,* with a guttural sound distinct from the foregoing (dog, cat); *Ná ná* (nurse—of course as proper, not generic name).

Dá dá was at first a vague demonstrative. I noted, however, with a query, man as a second and specialized meaning. About six weeks later it became a distinct proper name for the child's father, and has been consistently so used ever since. By this time the significance of pictures was in a general way understood. The child said *wah wah* to figures of animals, and attempted to smell at trees in the illustrations of the *Graphic.* (Six months later she pretends to feed the dogs in a picture.) The fact is curious, having regard to the inability of adult savages, as reported by many travelers, to make anything of even the simplest representations of objects. About this time the ticking of a watch gave great pleasure, and for some months afterward the child constantly begged to have one put to her ear, or, still better, to have it in her hand and put it there for herself. Five or six months later she had left off asking for it.

Fifteen months. *M-m* discontinued. Sometimes *bá bá* used instead; sometimes she simply cried for a desired object.

Imitative sounds to represent dog, cat, sheep, ticking of clock. *Wah wah, miau,* soon became generic names of dog and cat (*wah wah,* which at first included cat, becoming appropriated to dog). I think, however, *wah wah* would include any middling-sized quadruped other than a cat or a sheep. As to cat, her name for it became, a few months later, *aya-m* or *ayá-m,* which, so far as I know, she invented for herself. The conventional "gee-gee" for horse was very soon understood by her, though she could not form the *j* sound. She recognized a zebra in a picture-alphabet as "gee-gee," and showed marked dissent when told it was a zebra.

These imitative sounds were all learned on the suggestion of adults,

but studied from the real sounds; for as made by the child they are decidedly nearer to the real sounds than the *baa baa*, etc., used by adult voices.

"Baby" (or rather *bé bi*). This word was now formed with fair success, but soon dropped for a time. About a month afterward it was resumed, and became the child's name for herself. This was long before she attempted any other dissyllable. It was pronounced, however, rather as a reduplicated monosyllable.

Sixteen months. *Bâ* (ball), sometimes *ba*. *Tá* (1, thanks; 2, take, when offering something): this was deliberately taught her.

Playing with a ball became a favorite amusement at this time. She would throw a ball out of the window and expect it to be returned. When we tried a regular game of ball she seemed to think the point of the game was to get possession of the ball and keep it. A certain capacity for dramatic play was now first observed. The child knew the various animals in a toy menagerie by name, and would make believe to feed them with a spoon. About a month later she was taught a piece of rudimentary drama. The picture of the "little boy that cries in the lane" and gets no wool had fixed her attention in a book of nursery-rhymes, by this time constantly in hand, and now, on being asked, "What does the little boy that cries in the lane do?" she puts up her hands to her eyes and whimpers. She laughs afterward, which I think is fair evidence that she understands the performance and considers it a good joke.

Seventeen months. *Ni* (knee). This is a real word, used in a special and at the same time extended meaning. It signifies, *Take me on your knee and show me pictures;* and also expresses in a general way the idea of something (generally the cat) being on a person's lap, so that *ní* not unfrequently means, *I want to see the cat on your lap.* She also puts a toy dog on her knee and repeats *ní* several times with great satisfaction. About this time "baby" came to be freely used as an imperative or desiderative, combined with movements or gestures indicating an object—the sense being, *I* want that.

Seventeen to eighteen months. *Má má*, mother. I have no note of when this word began to be used (probably it was some months before this), but it was well established by this time at latest.

Ná ni or *ñá ni* (granny).

Pi (please). On learning to say "please" in this fashion the child left off putting her hands together to ask for things, which she had been taught to do before she could speak.

Pé pê, pencil (only once heard).

Pá pá. This was taught her as a synonym for *dá dá*, but she would not use it. Both "paper" and "pepper" (as common objects

at the breakfast-table) became in her mouth something not easily distinguished from *pá pá*. This may perhaps account for her unwillingness to take up the new name.

Ba or *bŏ*, book.

"More," or rather *mâ*, often prolonged to *mâ-a* or *mo-a*—to ask for more of some food, etc., or to ask for any action that pleased her to be repeated. This word enabled her to form an approach to a sentence: thus, *mâ . . . má má* ("more, mama").

Tá tá (taught her as the usual baby word for good-by, but extended by herself); always distinguished from the single *tá* noted above. *Tá tá* not only is used to say good-by, but expresses the general idea of going out-of-doors. Thus she says *tá tá* to her perambulator, and on seeing one take up a hat or overcoat.

A final nasal sound is now produced: she tries to say "down," what she does say being roughly *dáõ*—take me down from my chair—a very frequent request, as she can by this time walk easily, and is fond of running about the room.

The vocabulary is now increasing fast, and almost any word proposed to the child is imitated with some real effort at correctness. The range of articulate sounds is still very limited: *a*, *á*, *i* (short and long) are the only vowels fully under command; *â* occurs in a few words, and is the usual result of attempts to form *o:* thus, *nâ*—nose. The long sound of English *i* (*ai*) cannot be pronounced; when she tries to imitate it she says *iá* or *i-a*. No approach is yet made to the peculiar English short sound of *a* in such words as hat, bat. Of consonants *g*, *l*, *r* (the true consonant initial sound; the final semi-vowel, as in more, poor, is easy enough to her), and sibilants, aspirates, and palatals, are not yet mastered. "Guy" (a younger cousin's name) is called *dá*, or perhaps rather *ḍá*, the *ḍ* or *d* produced far back and apparently with effort; *k* is also produced far back in the mouth, with an approach to *t*. Final consonants are seldom or never given, and the vocabulary is essentially monosyllabic, the only exceptions being in the nature of proper names ("baby," *á-ni*, *ná-ná*), and even these are reduplicated monosyllables rather than dissyllables proper. She once said "lady" pretty well, but did not take it into use. No construction is yet attempted; the first approach to a sentence above noted has not been repeated. Even with these resources the child already contrives to express a good deal, filling up the meaning of her syllables with a great variety of tone, and also with inarticulate interjections. Impatience, satisfaction, disappointment, amusement, are all very well marked; and perhaps even intellectual dissent (in the case of "zebra" and "gee-gee," see above).

After this time (viz., her eighteenth birthday, reckoning birthdays by calendar months, as for this purpose is convenient) the child's progress became much more rapid, and it would not have been possible to take down all her new words without giving much more and more continuous attention than I had at my disposal. I also doubt if anything

would have been gained by it. The subsequent notes must be taken as being rather selections than a full record.

Eighteen to nineteen months. "Poor" (should perhaps have been set down earlier): no appreciable difference from ordinary adult pronunciation. *Dam* (gum), a word of large significance; see next paragraph.

"Poor" was taught as an expression of pity, but extended to mean any kind of loss, damage, or imperfection in an object, real or supposed. Some of her reasons for assuming imperfection were curious. She said "poor" to the mustard pot and spoon, taking, as we suppose, the movable spoon for a broken part. "Gum," on the other hand, with which toys are often mended, is conceived as a universal remedy for things broken or disabled. Later (at twenty-two and a half months) she says "poor" to a crooked pin, and on my beginning to straighten it, "dada mend."

The sound of *g* is now coming, and a final nasal is developed. "Down" is pretty well pronounced. *Ding*=dinner—not the meal or meal-time, but a toy dinner-service.

Bé bé=biscuit, with desiderative-imperative tone and meaning.

Nineteen months. *O* sound now distinctly made, and *g* distinct by the end of the month. "Guy" is now *gá* instead of *dá*. A final *l* once or twice observed: *t'ál*=shawl. Final *t* distinctly made: *hat* or *hŏt* (hot). Soon afterward *p* (in "top," pronounced *tap* or *tŏp*); *pu*=foot; after mastering final *t* she said *fat*. The monosyllabic form (one consonant and one vowel) still prevails. *K* is a favorite sound, and she has several words formed with it, which are carefully kept distinct. *Ku*=stool. *Kah* (later *kad*)=cod [liver oil], which she considers a treat. *Ko*="cozy" (on teapot); later *ka-zi* or *ka-zhi*. *Ká*=cold. *Ká ká*=chocolate. *Khi-en* or *kli-en*=clean; her first real dissyllable, for so she pronounced it. *Bé* for biscuit has now become *bek*. *Sh'ad* (thread). She has now observed the process of sewing, and tries to imitate it. Things broken, etc., are now divided into those which are to be mended with *dam* and those which are to be mended with *sh'ad*. Approach to *chu* (sugar) and *shu* (shoe, also sugar) sometimes quite distinct. I also note "jar" as well said, but *s*, *sh*, *ch*, *j*, are on the whole indistinct, and attempts to form them give curious palatal and sibilant sounds which I cannot write down. *W*, *v*, *f*, are now formed, but not well distinguished. *Vák* or *wák*=walk, *fák*=fork. Here also we get intermediate sounds. The *w* is often more German than English, though she cannot have heard the German *w* spoken.

The fork is a toy fork in the set of things generally called *ding* or *din*. But *fák* has another unexpected meaning. The child likes to look at an old illustrated edition of Dr. Watts's poems, and she has

turned "Watts" also into *fák*. It is possible, as M. Taine suggests, that to her there is some shade of difference in the sounds which escapes adult ears. At twenty months twenty-five days she said *vats* or *váts*. "Walk" has its proper sense as a mode of motion, opposed to riding, in perambulator for herself, or in carriage for others. She is much interested in watching callers going away, and says to them *dyi dyi* or *zhi zhi* (gee-gee) . . . *wák*, as if to ask how they mean to go; or, perhaps, merely to show her knowledge. Sometimes she begins to say *tá tá* to a visitor, not that she is tired of his or her presence, but that she wants the amusement of seeing the departure.

She has learned to repeat *no no* after she has been told not to do something, as an act of assent to the prohibition, and she seems to take pleasure in saying *no no* to the cat.

Twenty months. *Dash* or *dásh*=dust. *Ta'sh* or *tâ'sh*, learned, I think, from "touch," one day repeated several times without assignable meaning, and then dropped. *Tásh*, however, is adopted for [mus]tache. N. B.—Final sibilants are more under command than initial. Final *g* now produced: *geg*=fizgig (toy so called).

At this time a sudden advance was made to dissyllables. Several words were produced with success on or about the same day: "Fanny, honey, money" (these two learned from the rhyme of "Sing a song of sixpence"), very distinct. "Money," however, seems to be confused with "moon:" when told to say moon she says money. Others are attempted with more or less success: as *fá-wá*, flower; *la-ta*, letter; *ha-pi*, happy (taught her as opposite of "poor," but I doubt if she sees the meaning. She has taken up *ha-pi* to stand for "empty," which we tried to teach her, and in that sense uses it without prompting). *Bá-ta*, butter. The child's own name, Alice, is given as *A-si*, or perhaps *A-śi* (later *á-si*). As to sound, she is now acquiring the English long sound of *i* (*ai*). *R* is still impracticable, and attempts to form it sometimes give *d* (but this was very transient, and *l* soon became the common substitute): compare the converse Bengalese treatment of Sanskrit *d*, which, I believe, is in Bengal regularly pronounced as *r*. "P'ram," for perambulator, becomes *thlam:* the *th*, with an extra aspiration, almost *χθ*. A few weeks later this was simplified into *khlam*. There seems to be a difficulty about initial vowels: "egg" becomes *lleg* (or perhaps *yleg* would be nearer), which I can only write symbolically: the sound marked as *ll* or *yl* is something like the Spanish *ll* with an aspiration. A few days later the initial sound was more sibilant and less vocal, say (symbolically) *zhy*.

Early in March (at twenty months) we noted the first attempt at sustained conversation. The child was looking, or pretending to look, for a lost object on the floor. We told her she would get her hands dirty. On this she exclaimed, in a tone of dissenting interrogation, "Dirty!" (*da-ti*), and then, after looking at her hands, holding them

out to us, and with triumphant affirmation, "Clean!" (*kle'n*). Here we have not merely vocal signs, but intercourse by speech—one may say an elementary form of repartee and argument. She can now say "yes" (*es*, or *is*, sometimes *as*) and "no" in answer to questions with fair intelligence, though she sometimes answers at random, and sometimes gives the wrong answer on purpose for a joke. One of her new words is *fa-ni* (funny), which she uses in a wider sense than adults, for anything that pleases and surprises her. The imitative name for the cat is dropped, and she now says (for "pussy") *pū-si* (*ū* as in South-German, coming very near to *i*). "Funny" is also used to disguise fear, e. g., on being introduced to a strange dog. When left to play alone she talks to herself constantly. The staple of one of these monologues (March 10th) was *á-diá* (formed on "O dear"). I half suspect a dramatic intention in her proceedings.

The peculiar short sound of English *a* (represented by *æ* in Mr. Ellis's general notation) is now forming. She can say "bag" nearly like an adult. But, as a rule, she still substitutes (Indian) *a* or *á*, saying, e. g., "cub," or "kahb," for "cab."

Twenty-one months. Progress is now less marked and rapid. New words continue to be acquired, but the power of putting them together does not seem to increase much. The child is, however, now more or less able to answer direct as distinguished from leading questions. Thus, when she had been paying a visit to some relations and cried to go home, she gave afterward (March 17th) a pretty connected account of it in monosyllabic answers. *Q.* What did you do to-day at ——? *A. Klai* ("cry"). *Q.* And what did you cry for? *A. Ham* ("home," i. e., I cried to go home). Also, when told not to handle a forbidden object, such as a knife, she will say, in a tone of intelligent acquiescence: *No—dá dá* (i. e., I may not have that, but *dá dá* may). One trisyllable is in common use: *Tenisi*=Tennyson, an illustrated edition, which divides her attention with *Vats* (Watts).

As to sounds, *r* is generally replaced by *l* or *ll*, or (approximately) *hl: hlan* or *llan*="run." The prosthetic initial sound for words beginning with vowels is now *zh*, or an aspirated *y*.

She begins, too, to put now and then a substantive and adjective together: "clever baby," "happy man" (in picture); the meaning of which she now seems to understand well enough.

Twenty-one and a half months. There is now a distinct advance in constructive power. Substantives and adjectives are freely put together (e. g., "dirty boots"), and I have noted one instance of the use of a real predicate, so as to form a complete proposition. The child had been told, half in joke, that cabs were dirty as compared with her perambulator. For some days she had been accustomed to say "dirty" on the mention of cab, "clean" on the mention of perambulator. Now

she made the whole statement for herself: *Kábz dati klam*[1] *klín* ("cabs dirty, peram' clean"). She still talks constantly to herself, and with a continuity giving more or less evidence of continuous trains of thought. I am informed of dramatic conversations with her doll, such as pretending to make it look at things, and describing them to it.

The doll furnishes an illustration of the process of making generic names. A doll was named "Bessie," in honor of the donor; some time afterward another doll was given by another person. The child insisted on calling this "Bessie," too. She does not seem to feel the want of a specific distinction between the two dolls; when she does wish to speak of one as distinct from the other, she says "other Bessie." In like manner, *bet* (bacon) is used with a generalized meaning, nearly = ὄψον, to denote any dish that appears at breakfast.

Twenty-two months. Vocabulary and power of expression are gradually and steadily extending. A certain number of the words called symbolic by some recent philologists have been mastered: "now," "there," "other," or "'nother," are in constant use; the child often says "there it is" (in the compendious form, *zhátis*), and almost always adds "now" to the statement of anything she wants (e. g., "Bring—cake—now"). "Again" is also in use, though not quite so much. The following approach to a complex sentence is reported: "Out—pull—baby—pecs" (spectacles). Simpler combinations are freely used: subject and verb, as "run away man;" or, subject, verb, and *régime*, as "mama get Bessie." The sense is generally optative or imperative, but sometimes indicative. She often says *es es* (yes) to emphasize her demands, as: "Es es—baby's book there."

Articulation is firmer, and very distinct. She says "good-by" better than most adults, but making two separate words of it, and dwelling strongly on the "good." The vowel-range is increased, but *a*, *á*, are still favorite sounds. Of consonants *ch*, *j*, and *th* (both sounds), are still imperfect (*th* hard mostly becomes *s*, *th* soft, *z*), and consonantal *r* is not yet formed at all.

At twenty-two months one day, a real verbal inflection was used. She said of a younger child, "naughty baby;" and being asked why it was naughty answered without hesitation, *klaid* (cried). That she appreciates the general force of the inflection is shown about a week later by her using "comed" for the participle "come."

At twenty-two months ten days, a sentence is noted *ex relatione*, containing not only a direct but an indirect *régime:* "Annie—gave—baby—sugar;" and again, a day or two later, "Dada give *bátá* (butter, i. e., bread and butter) baby." Talk to the doll is now very common, as, "Bessie look," "Bessie walk away:" sometimes the child repeats to the doll what has been said to her by elders. She also puts the doll

[1] Simple *k* is now substituted for the initial *kh* in this word; which again, as noted above, had replaced a more complicated aspirate sound.

to bed, takes it out for a walk and brings it home, etc. On one occasion she scolded it for two or three minutes, saying "naughty Bessie" with much gravity. We could not discover what the supposed offense was. I may observe on this that I have no reason to doubt that all the play with her doll is purely and consciously dramatic, not animistic; in other words, I have seen nothing to indicate a belief that the doll is really alive, nor is there, so far as I can observe, any tendency to attribute life to other inanimate objects. I think the child is perfectly aware of the difference between animals and things, though I am unable to give specific reasons for this impression. "Again" is now used to strengthen "more:" when she wants anything repeated she says "more 'gain." The following is an actual short conversation, on seeing an ivory ring spun teetotum-wise: "Baby do't . . . [after failure to make it spin herself] more 'gain . . . ma-ma 'gain . . . ma-ma do't . . . [then turning to another object of interest] . . . baby's *bâts* (basket) . . . ma-ma, take off cover." Command of general and symbolic language continues to make almost daily progress. *Zât sing* (that thing) is now used to call attention to any desired object, the name of which has not been mastered.

At twenty-two and a half months, besides the dramatic play with the doll, we have now some quasi-dramatic imitation of grown-up people's action. For some time the child has been accustomed to bring the newspaper to the breakfast-table, and she always pretends to read it herself before handing it over. To-day, seeing her mother writing, she scratched the paper with a dry pen, saying, "Baby *lait* (write) ma-ma's letter."

Twenty-three months. Fluency and command of language increase. We note the first appearance of a *question*, viz.: "Where's pussy? baby look up-'tairs."

The palatals, dental aspirates, and the peculiar English short *a* (as in "hat") are still imperfect, and *r* is represented by *l*. When *s* comes before another consonant, one of the two is dropped. *K* is in some words confused with *p* or *t*. She says "oken" for "open," "kek" for "take."

The child takes pleasure in quasi-dramatic games and actions with her parents as well as with her doll. Sometimes, when saying good-night, she pretends to refuse a kiss, and lets me make a *fausse sortie*, as if annoyed or indifferent, and then calls "dada come back" (or "comed," for she uses this form for present and past indiscriminately, which compels me to set a lower value on her appreciation of inflections), and gives the kiss after all. (At twenty-three and a half months, however, she uses "made" correctly). I think she considers the thing a joke, but not without a shade of fear that it may be taken seriously. The last time, she completed the performance by saying "goody girl" in a tone of extreme self-complacency.

Seeing lines of dots on a printed page, thus . . . (in a table of contents), she said, "Oh! pins," and made repeated attempts to pick them out. This would seem to have some bearing, however slight, on the gradual character of the process by which our vision of solid objects and perceptions of things as in three dimensions is acquired.

She now has a settled formula to ask for things she wants, and also to express acquiescence when told she is not to have them, e. g., "baby have *pápá* (pepper)," "baby have *pápá* no." The "no" is not given as it would be by an adult, as a distinct exclamation following a pause. There is no stop and no raising of the voice. When she is impatient, "baby have, baby have, baby have," is rapidly repeated. She is very persistent in trying to get a desired object, and if she cannot have it at once does not give it up, but proceeds to make the best terms she can; e. g., she asks for bacon, and is told it is not for her, but her parents must have it first. She answers, "*then* baby have bacon." Here is an elementary notion of bargain and compromise. The child is already *πολιτικὸν ζῶον*.

Bacon has lost its former generality, meats which appear at breakfast being now divided into egg, bacon, *sis* (fish), and beef. Once, after calling a new dish "bacon," and being corrected, she said "bacon no"—recognizing, one may say, the logical division into bacon and not-bacon. The child is now able, however, to take up new words very quickly. She has reached, so far as concerns the names of things, the advanced stage of knowledge in which the provisional character of generalizations is recognized.

At about twenty-three months ten days she cried violently on finding that her doll's head was coming off, and was pacified only when it was put out of sight with a promise that it should be mended. Her own report of the cause of her grief was "Bessie's head poor." The dramatic personification of the doll may probably count for something in this. But one is not strictly entitled to assume that she would cry less for damage to any other toy.

There are increasing signs of a desire to find explanations. Seeing in an illustrated advertisement a device of a griffin rampant supporting a kind of banner, the child invented a meaning of her own for it: "pussy *ling* (ring) bell." The figure of a man making pottery, which was part of the same advertisement, became "man open door," so as to form a single composition with the griffin. On hearing sounds in the street, knocks at the door, etc., the child readily (and, as a rule, spontaneously) assigns causes for them, saying "band," "organ," "man," "post," etc., as the case may be. Strange sounds, and at times sounds of a known class coming from an unfamiliar direction, appear to frighten her.

I should add that the greater part of these notes was already written before I saw M. Bernard Perez's very interesting book, "Les trois premières Années de l'Enfant" (Paris, 1878). I have retouched

and rearranged them as little as possible, preferring the certainty of leaving them in an inartificial state to the risk of spoiling by manipulation whatever value they may possess as records made at the time.—*Mind.*

THE ORIGIN OF FRUITS.

By Professor GRANT ALLEN.

IN the whole museum of Nature the eye of the artist can find nothing lovelier than flowers; but the second rank in beauty may be fairly claimed on behalf of fruits. Whether we look at the golden oranges, the pink-cheeked mangoes, the purple star-apples, and the scarlet capsicums of the south, or at our own crimson cherries, blushing grapes, bright holly-berries, and rosy apples, we are equally struck with the delicacy of their melting tints and the graceful curves of their rounded form. Our painters have reveled in their rich coloring; and even our sculptors, whose fastidious art compels them to reject that meretricious charm, have loved to chisel their swelling contours in snowy stone. As they hang pendent from their native boughs, clustering in brilliant masses, or scattered here and there as points of brighter light amid the dark foliage which throws up in strong relief their exquisite hues, we may recognize in their beauty the ultimate source of all that refined pleasure which mankind derives from the varied shades of earth and sea and sky, of flower and bird and butterfly, and even of the "human face divine" itself. From the contemplation of ruddy or snowy berries in primeval forests the frugivorous ancestors of our race first acquired the taste for brilliant hues, whose final outcome has produced at length our modern picture-galleries and palaces, our flower-gardens and conservatories, our household ornament and our decorative art.

In a previous paper on "The Origin of Flowers,"[1] we endeavored to trace the mutual reactions of insects and blossoms upon one another's forms and hues. But we then deferred for a while the consideration of the further question—"Why do human beings admire these bright whorls of colored leaves, whose primitive function consisted in the attraction of bees and butterflies? Through what community of origin or nature does the eye of man find itself agreeably stimulated by the tints which were first developed to suit the myriad facets of primeval insects?" The answer to this question we have now to attempt, by showing the various steps through which the coverings of certain seeds acquired, for the vertebrate orders—the birds and quadrupeds—exactly the same allurements of color, scent, and taste, which flowers had already acquired for the articulate orders—the bees and butterflies.

[1] *See* Popular Science Monthly Supplement, No. XIV., p. 151.

To the attractive hues of fruit, I believe, we must ultimately trace back our whole artistic pleasure in the pure physical stimulation of beautiful colors, displayed by natural objects or artificial products.

Our present inquiry, then, will yield us some account of that primitive delight in red, purple, orange, and yellow, which we usually take for granted as an innate instinct of humanity, savage or civilized. When, some few months back, we analyzed the various elements of pleasure which make up our æsthetic enjoyment of a daisy, we were compelled, for the time being, to leave the original beauty of its pink-and-white rays wholly unexplained. We regarded the delight in color, relatively to the subject we were then examining, as an ultimate and indecomposable factor in our developed consciousness. To-day, however, I hope we shall be able to go a little further back, and to show that this delight, like all other feelings of our nature, is no mere chance and meaningless accident, but the slow result of a long adaptation whereby man has gradually become fitted to the high and responsible station which he now occupies at the head of organic existence.

The sole object of flowering is the production of seeds—that is to say, of embryo plants, destined to replace their parents, and continue the life of their species to future generations. Flowers and seeds go together; every flower producing seed, and every seed springing from a flower. Ferns and other like plants, which have no blossoms, bring forth spores which grow into shapeless little fronds, instead of true seeds containing a young plantlet. But all flowering species produce some kind of genuine fruit, supplied with more or less nutriment for the tender embryo in its earlier days. And this matter of nutriment is so important to a right comprehension of our subject that I venture, even at the imminent peril of appearing dull, to digress a little into the terrible mysteries of Energy, which comprise the whole difficulty of the question.

Wherever movement is taking place in any terrestrial object, the energy which moves it has been directly or indirectly supplied from the sun. In the green parts of plants, the solar rays are perpetually producing a separation of carbon and oxygen, the former element being stored up in the tissues themselves, while the latter is turned loose upon the atmosphere in a free state. Whenever they recombine, motion and heat will result, as we see alike in our grates, our steam-engines, and our own bodies. An animal is a sort of machine—viewed from a purely physical standpoint—in which the energetic materials laid up by plants are being reconverted into the warmth which reveals itself to our touch, and the evident movement which we see in its limbs. The vegetable or animal substances which are capable of yielding these energies to our bodies we know as food or nutriment. They perform exactly the same part in the physical economy of men or beasts as that which fuel performs in the physical economy of the steam-engine. Of course, from the *mental* point of view, we have the

immense difference between a self-conscious, self-guiding organism, and a dead machine requiring to be supplied and regulated by an external consciousness; yet in the fundamental physical necessity for energetic material, either as food or as fuel, both mechanisms follow essentially the self-same mechanical laws.

But what has all this to do with the origin of fruits? Very little at first sight, indeed, yet everything when we look at the bottom of the question. In fact, what is thus true of animals and steam-engines is equally true of plants. No motion can take place in a growing shoot without the aid of solar energy, directly supplied by the sunshine, or indirectly laid by in the older tissues. In the green parts of a plant this energy is immediately derived from the bounteous light which bathes and vivifies the leaves on every side; but in many other portions of the vegetable organism, energies previously accumulated by older organs are perpetually being utilized, for the production of movement and growth, by lazy structures which cannot work for themselves, and so feed upon the useful materials collected for them by more industrious members of the plant-commonwealth. Especially is this the case with those expensive organs which are concerned in perpetuating the species to future generations. A flower or a seed cannot directly transform waves of light into chemical separation of atoms; they depend for their growth and the due performance of their important functions upon similar separations already carried on for their behoof by the green leaves on whose bounty they rely for proper subsistence. Carbon, set free from oxygen in the leaves, has been carried to them in loose combinations by the sap; and as the bud unfolds or the seed germinates, the oxygen once more unites with this carbon (just as it unites in the furnace of the steam-engine, or the recesses of the animal body), and motion is thereby rendered possible. But without such an access of free oxygen to recombine with the energetic materials, the blossom or the embryo could never grow at all. So we may regard these portions of a plant, incapable of self-support, and dependent for their due function upon energetic compounds laid by elsewhere, as the exact analogues of the animal or the steam-engine. They are in fact similar mechanisms, where food is being used up, and fuel is being consumed; and we find accordingly, as we might naturally expect, not only that motion results, but also that heat is evolved in quantities quite sufficient to be measured by very delicate thermometers.

Now, every growing portion of a plant shares, more or less, in this animal function of feeding upon previously-fabricated nutriment. But there are two sets of organs, both intended ultimately to subserve the same purpose, in which that function becomes especially apparent. The first is in the case of the whole regular reproductive mechanism, including in that term buds, flowers, fruits, and seeds; the second is in the case of such subsidiary reproductive devices as tubers, rhizomes, corms, and all the other varieties of underground stems or roots, which

botanists divide into so many puzzling technical classes, while ordinary people are content to lump them roughly together as bulbs. If we glance briefly at each of these two cases, we shall be able to comprehend more fully their connection with the doctrine of energy, and also to see more clearly the problem before us when we endeavor to unravel the origin of fruits.

A germinating pea or a young blade of wheat is supplied by its parent with a large stock of nutriment in the shape of starch, albumen, or other common food-stuffs. If we were to burn the wheat instead of planting it, the energy contained in its substance would be given off during the act of combustion as light and heat. If, again, we were to adopt a more usual course, by grinding, baking, and eating it, then the inclosed energy would minister to the warmth of our bodies, and do its little part in enabling us to walk a mile or to lift a heavy weight. But if, in lieu of either plan, we follow the original design of Nature by covering the seed with moist earth, the chemical changes which take place within it, still resulting in heat and motion, produce that special form of movement which we know as germination. New cells form themselves about the feathery head, a little sprout pushes timidly its way through the surrounding soil, and soon a pair of rounded leaves or a spike of pointed blades may be seen spreading a mass of delicate green toward the open sunlight overhead. By the time that all the stored-up nutriment contained in the seed has been thus devoured by the young plantlet, these green surfaces are in a position to assimilate fresh material for themselves, from the air which bathes them on every side, under the energetic influence of the sunbeams that fall each moment on their growing cells. But I need hardly point out the exact analogy which we thus perceive between the earliest action of the young plant and the similar actions of the frugivorous animals which subsist upon the food intended for its use.

If, however, we look at the second great case, that of bulbs and tubers, we shall see the same truth still more clearly displayed. You cannot grow a blade of wheat or a sprouting pea in the dark. The seed will germinate, it is true; but, as soon as the primitive store of nutriment has been used up, it will wither away and die. Naturally enough, when all its original energy is gone, and no new energy is afforded to it from without in the form of sunshine, it cannot miraculously make growth for itself out of nothing. But if you put a hyacinth-bulb in a dark cellar, and supply it with a sufficiency of water, it will grow and blossom almost as luxuriantly as in a sunny window. Now, what is the difference between these two cases? Simply this: the wheat-grain or the pea has only nutriment enough supplied it by the parent-plant to carry it over the first few days of its life, until it can shift for itself; while the hyacinth has energetic materials stored up in its capacious bulb to keep it in plenty during all the days of its summer existence. If we plant it in an open spot where it can bask in the

bright sunshine, it will produce healthy green leaves, which help it to flower and to carry on its other physiological actions without depending entirely upon its previous accumulations; but if we place it in some dark corner, away from the sun, though its leaves will be blanched and sickly-looking, it will still have sufficient nutriment of its own to support it through the blossoming season without the external aid of fresh sunshine.

Where did this nutriment come from, however? It was stored up, in the case of the seed, by the mother-plant; in the case of the bulb, by the hyacinth itself. The materials produced in the leaves were transferred by the sap into the flower or the stem, and were there laid by in safety till a need arose for their expenditure. All last year—perhaps for many years before—the hyacinth-leaves were busily engaged in assimilating nutritive matter from the air about them, none of which the plant was then permitted to employ in the production of a blossom, but all was prudently treasured up by the gardener's care in the swelling bulb. This year, enough nourishment has been laid by to meet the cost of flowering, and so our hyacinth is enabled to produce, through its own resources, without further aid from the sun, its magnificent head of bright-colored and heavily-scented purple bells.

Each species of plant must, of course, solve for itself the problem, during the course of its development, whether its energies will be best employed by hoarding nutriment for its own future use in bulbs and tubers, or by producing richly-endowed seeds which will give its offspring a better chance of rooting themselves comfortably, and so surviving in safety amid the ceaseless competition of rival species. The various cereals, such as wheat, barley, rye, and oats, have found it most convenient to grow afresh with each season, and to supply their embryos with an abundant store of food for their sustenance during the infant stage of plant-life. Their example has been followed by peas and other pulses, by the wide class of nuts, and by the majority of garden-fruits. On the other hand, the onion and the tiger-lily store nutriment for themselves in the underground stem, surrounded by a mass of overlapping or closely-wound leaves, which we call a bulb; the iris and the crocus lay by their stock of food in a woody or fleshy stalk; the potato makes a rich deposit of starch in its subterraneous branches or tubers; the turnip, carrot, radish, and beet, use their root as the storehouse for their hoarded food-stuffs; while the orchis produces each year a new tubercle by the side of its existing root, and this second tubercle becomes in turn the parent of the next year's flowering stem. Perhaps, however, the common colchicum or meadow-saffron affords the most instructive instance of all; for during the summer it sends up green leaves alone, which devote their entire time to the accumulation of food-stuffs in a corm at their side; and, when the autumn comes round, this corm produces, not leaves, but a naked flower-stalk, which pushes its way through the moist earth, and stands solitary before the October winds,

depending wholly upon the stock of nutriment laid up for it in the corm.

If we look at the parts of plants which are used as food by man or other mammals, we shall see even more clearly the community of nature between the animal functions and those of seeds, flowers, and bulbs. It is true that the graminivorous animals, like deer, sheep, cows, and horses, live mainly off the green leaves of grasses and creeping plants. But we know how small an amount of food they manage to extract from these fibrous masses, and how constantly their whole existence is devoted to the monotonous and imperative task of grazing for very life. Those animals, however, who have learned to live at the least cost to themselves always choose the portions of a plant which it has stored with nourishment for itself or its offspring. Men and monkeys feed naturally off fruits, seeds, and bulbs. Wheat, maize, rye, barley, oats, rice, millet, peas, vetches, and other grains or pulses, form the staple sustenance of half mankind. Other fruits largely employed for food are plantains, bananas, bread-fruit, dates, cocoanuts, chestnuts, mangoes, mangostines, and papaws. Among roots, tubers, and bulbs, stored with edible materials, may be mentioned beets, carrots, radishes, turnips, swedes, ginger, potatoes, yam, cassava, onions, and Jerusalem artichokes. But if we look at the other vegetables used as food, we shall observe at once that they are few in number, and unimportant in economical value. In cabbages, Brussels sprouts, lettuce, succory, spinach, and water-cress, we eat the green leaves; yet nobody would ever dream of making a meal off any of these poor food-stuffs. The stalk or young sprout forms the culinary portion of asparagus, celery, seakale, rhubarb, and angelica, none of which vegetables are remarkable for their nutritious properties. In all the remaining food-plants, some part of the flowering apparatus supplies the table, as in true artichokes, where we eat the receptacle, richly stocked with nutriment for the opening florets; or in cauliflower, where we choose the young flower-buds themselves. In short, we find that men and the higher animals generally support themselves upon those parts of plants in which energy has been accumulated either for the future growth and unfolding of the plant itself, or for the sustenance of its tender offspring.

And now, after this long preamble, let us come back to our original question, and seek to discover what is the origin of fruits.

In botanical language, every structure which contains the seeds resulting from the fertilization of a single blossom is known as a fruit, however hard, dry, and unattractive, may be its texture or appearance. But I propose at present to restrict the term to its ordinary meaning in the mouths of every-day speakers, and to understand by it some kind of succulent seed-covering, capable of being used as food by man or other vertebrates. And our present object must be simply to discover how these particular coverings came to be developed in the slow course of organic evolution.

Doubtless the earliest seeds differed but little from the spores of ferns and other flowerless plants in the amount of nutriment with which they were provided and the mode in which they were dropped upon the nursing soil beneath. But as time went on, during the great secondary and tertiary ages of geology, throughout whose long course first the conifers and then the true flowering plants slowly superseded the gigantic horsetails and tree-ferns of the coal-measures, many new devices for the dispersion and nutrition of seeds were gradually developed by the pressure of natural selection.[1] Those plants which merely cast their naked embryos adrift upon the world to shift for themselves in the fierce struggle of stout and hardy competitors must necessarily waste their energies in the production of an immense number of seeds. In fact, calculations have been made which show that a single scarlet corn-poppy produces in one year no less than 50,000 embryos; and some other species actually exceed this enormous figure. If, then, any plant happens by a favorable combination of circumstances to modify the shape of its seed in such a manner that it can be more readily conveyed to open or unoccupied spots, it will be able in future to economize its strength, and thus to give both itself and its offspring a better chance in the struggle for life. There are many ways in which natural selection has effected this desirable consummation.

The thistle, the dandelion, and the cotton-bush, provide their seeds with long tufts of light hair, thin and airy as gossamer, by which they are carried on the wings of the wind to bare spaces, away from the shadow of their mother-plant, where they may root themselves successfully in the vacant soil. The maple, the ash, and the pine, supply their embryos with flattened wings, which serve them in like manner not less effectually. Both these we may classify as *wind-dispersed* seeds. A second set of plants have seed-vessels which burst open explosively when ripe, and scatter their contents to a considerable distance. The balsam forms the commonest example in our European gardens; but a well-known tropical tree, the sand-box, displays the same peculiarity in a form which is almost alarming, as its large, hard, dry capsules fly apart with the report of a small pistol, and drive out the disk-shaped nuts within so forcibly as to make a blow on the cheek decidedly unpleasant. These we may designate as *self-dispersed* seeds. Yet a third class may be conveniently described as *animal-dispersed*, divisible once more into two sub-classes, the involuntarily and the voluntarily aided. Of the former kind we have examples in those seeds which, like burs and cleavers, are covered with little hooks, by whose assistance they attach themselves to the fur or wool of passers-by. The latter or voluntarily aided sort are exemplified in fruits proper, the subject of our

[1] I trust that in the sequel the critical botanist will excuse me for having neglected the strict terminology of carpological science, and made no distinction between seeds and fruits. Some little simplification is absolutely necessary for general readers in this the most involved department of structural botany.

present investigation, such as apples, plums, peaches, cherries, haws, and bramble-berries. Every one of these plants is provided with hard and indigestible seeds, coated or surrounded by a soft, sweet, pulpy, perfumed, bright-colored, and nutritious covering, known as fruit. By all these means the plant allures birds or mammals to swallow and disperse its undigested seed, giving in, as it were, the pulpy covering as a reward to the animal for the service thus conferred. But before we go on to inquire into the mode of their development we must glance aside briefly at a second important difference in the constitution of seeds.

If we plant a grain of mustard-seed in moist earth and allow it to germinate, we shall see that its young leaves begin from the very first to grow green and assimilate energetic matter from the air around them. They are, indeed, compelled to do so, because they have no large store of nutriment laid up in the seed-leaves for their future use by the mother-plant. But if we treat a pea in the same manner, we shall find that it long continues to derive nourishment from the abundant stock of food treasured up in its big, round seed-leaves. Now of course any plant which thus learns to lay by in time for the wants of its offspring gives its embryo a far better chance of surviving and leaving descendants in its turn, than one which abandons its infant plants to their own unaided resources in a stern battle with the unkindly world. Exactly the same difference exists between the two cases as that which exists between the wealthy merchant's son, launched on life with abundant capital accumulated by his father, and the street Arab, turned adrift, as soon as he can walk alone, to shift or starve for himself in the lanes and alleys of a great city.

So, then, as plants went on varying and improving under the stress of over-population, it would naturally result that many species must hit independently upon this device of laying by granaries of nutriment for the use of their descendants. But side by side with the advancing development of vegetable life, animal life was also developing in complexity and perfect adaptation to its circumstances. And herein lay a difficult dilemma for the unhappy plant. On the one hand, in order to compete with its neighbors, it must lay up stores of starch and oil and albumen for the good of its embryos; while, on the other hand, the more industriously it accumulated these expensive substances, the more temptingly did it lay itself open to the depredations of the squirrels, mice, bats, monkeys, and other clever thieves, whose number was daily increasing in the forests round about. The plant becomes, in short, like a merchant in a land exposed to the inroads of powerful robbers. If he does not keep up his shop with its tempting display of wares, he must die for want of custom; if he shows them too readily and unguardedly, he will lay himself open to be plundered of his whole stock-in-trade. In such a case, the plant and the merchant have recourse to the self-same devices. Sometimes they surround themselves with

means of defense against the depredators; sometimes they buy themselves off by sacrificing a portion of their wealth to secure the safety of the remainder. Those seeds which adopt the former plan we call *nuts*, while to those which depend upon the latter means of security we give the name of *fruits*.

A nut is a hard-coated seed, which deliberately lays itself out to escape the notice and baffle the efforts of monkeys and other frugivorous animals. Instead of bidding for attention by its bright hues, like the flower and fruit, the nut is purposely clad in a quiet coat of uniform green, indistinguishable from the surrounding leaves, during its earlier existence; while afterward it assumes a dull-brown color as it lies upon the dusky soil beneath. Nuts are rich in oils and other useful food-stuffs; but to eat these is destructive to the life of the embryo; and therefore the nut commonly surrounds itself with a hard and stony shell, which defies the stoutest teeth to pierce its thickened walls. Outside this solid coating it often spreads a softer covering with a nauseous, bitter taste, so familiar to us all in the walnut, which at once warns off the enemy from attacking the unsavory morsel. Not content with all these protective devices, of color, taste, and hardness, the nut in many cases contains poisonous juices, and is thickly clad in hooked and pointed mail, which wounds the hands or lips of the would-be robber. In brief, a nut is a seed which has survived in the struggle for life by means of multiplied protections against the attacks of enemies. We cannot have a better instance of these precautions than the common cocoanut palm. Its seed hangs at a great height from the ground, on a tall and slender stem, unprovided with branches which might aid the climber, and almost inaccessible to any animal except the persevering monkey. Its shell is very thick and hard, so extremely impermeable that a small passage has to be left by which the germinating shoot may push its way out of the stronghold where it is born. Outside this shell, again, lies a thick matting of hairy fibres, whose elasticity breaks its fall from the giddy height at which it hangs. Yet, in spite of all these cunning precautions, even the cocoanut is not quite safe from the depredations of monkeys, or, stranger still, of tree-climbing crabs. The common Brazil-nuts of our fruiterers' shops are almost equally interesting, their queer, shapeless forms being closely packed together, as they hang from their native boughs, in a hard outer shell, not unlike that of the cocoanut. It must be very annoying to the unsuspecting monkey, who has succeeded after violent efforts in breaking the external coat, to find that he must still deal with a mass of hard, angular, and uncanny nuts, which sadly cut his tender gums and threaten the stability of his precious teeth—those invaluable tools which serve him well in the place of knives, hammers, scissors, and all other human implements.

A fruit, on the other hand, lays itself open in every way to attract the attention of animals, and so to be dispersed by their aid, often amid the nourishing refuse of their meals. It is true that, with the fruit as

with the nut, to digest the actual seed itself would be fatal to the life of the young plant. But fruits get over this difficulty by coating their seeds first with a hard, indigestible shell, and then with a soft, sweet, pulpy, and nutritious outer layer. The purely accidental or functional origin of this covering is testified by the immense variety of ways in which it has been developed. Sometimes a single seed has shown a slight tendency to succulence in its outer coat, and forthwith it has gone on laying up juices from generation to generation, until it has developed into a one-seeded berry. Sometimes a whole head of seeds has been surrounded by a fleshy stem, and the attention of animals has thenceforward encouraged its new habit by insuring the dispersion of its embryos. A few of the various methods by which fruits attain their object we shall examine in detail further on; it will suffice for the present to point out that any property which secured for the seed dispersion by animal agency would at once give it an advantage over its fellows, and thus tend to be increased in all future generations.

So, then, as birds, squirrels, bats, monkeys, and the higher animals generally, increased on the face of the earth, every seed which showed a tendency to surround itself with succulent pulp would obviously gain a point thereby in its rivalry with other species. Accordingly, as we might naturally expect, fruits, which have been developed to suit the taste of birds and mammals, are of much more recent geological origin than flowers, which have been developed to suit the taste of insects. For example, there is no family of plants which contains a greater number of fruity seeds than the rose tribe, in which are comprised the apple, pear, plum, cherry, blackberry, raspberry, strawberry, quince, medlar, loquat, peach, apricot, and nectarine, besides the humbler hips, haws, sloes, and common hedge-fruits, which, though despised by lordly man, form the chief winter sustenance of such among our British birds as do not migrate to warmer climates during our chilly December days. Now, no trace of the rose tribe can be discovered until late in tertiary times; in other words, no fruit-bearers appear before the evolution of the fruit-eaters who called them into existence: while, on the other hand, the rapid development and variation of the tribe in the succeeding epoch show how great an advantage it derived from its tendency to produce edible seed-coverings.

But not only must these coverings be succulent and nutritious, they must also be conspicuous and alluring. For the attainment of these objects the fruit has recourse to just the same devices which had already been so successfully initiated by the insect-fertilized flowers. It collects into its pulpy substance a quantity of that commonly-diffused vegetable principle which we call sugar. Now sugar, from its crystalline composition, is peculiarly adapted for acting upon the exposed nerves of taste in the tongue of vertebrates; and the stimulation which it affords, like all healthy and normal ones, when not excessive in amount, is naturally pleasurable to the excited sense. Of course, in

our own case, the long habituation of our frugivorous ancestors to this particular stimulant has rendered us peculiarly sensitive to its effects. But even from the first, there can be little doubt that a body so specially fitted to arouse sensation in the gustatory nerve must have afforded pleasure to the unspecialized palates of birds and rodents: for we know that even in the case of naturally carnivorous animals, like dogs, a taste for sugar is extremely noticeable. So, then, the sweet juices of the fruit were early added to its soft and nutritive pulp as an extra attraction for the animal senses.

Perfume, of course, follows in the wake of sweetness. Indeed, the difference between taste and smell is much smaller than most people imagine. When tiny floating particles of a body, in the gaseous state, affect certain exposed nerves in the cavity of the nose, we call the resulting sensation an odor; when larger particles of the same body, in the liquid or dissolved state, affect similar exposed nerves in the tongue, we call the resulting sensation a taste. But the mechanism of the two senses is probably quite similar, while their exciting causes and their likes or dislikes are almost identical. As our great psychological teacher, Mr. Herbert Spencer, well puts it, "smell is anticipatory taste." So we need not be surprised to find that the delicate fragrance of peaches, strawberries, oranges, and pineapples, is a guide to their edibility, and a foreshadowing of their delicious flavor, leading us on by an instinctive action to place the savory morsels between our lips.

But the greatest need of all, if the plant would succeed in enticing the friendly parrot or the obsequious lemur to disperse its seed, is that of conspicuousness. Let the fruit be ever so luscious and ever so laden with sweet sirups, it can never secure the suffrages of the higher animals if it lies hidden beneath a mass of green foliage, or clothes itself in the quiet garb of the retiring nut. To attract from a distance the eyes of wandering birds or mammals, it must dress itself up in a gorgeous livery of crimson, scarlet, and orange. The contrast between nuts and fruits is exactly parallel to the contrast between the wind-fertilized and the insect-fertilized flowers. An apple-tree laden with its red-cheeked burden, an orange-bough weighed down with its golden spheres, a rowan or a holly-bush displaying ostentatiously its brilliant berries to the birds of the air, is a second edition of the roses, the rhododendrons, and the May-thorns, which spread their bright petals in the spring before the fascinated eyes of bees and butterflies. Some gay and striking tint, which may contrast strongly with the green foliage around, is needed by the developing fruit, or else its pulpiness, its sweetness, and its fragrance, will stand it in poor stead beside its bright-hued compeers.

How fruits began to acquire these brilliant tints is not difficult to see. We found already in the case of flowers that all external portions of a plant, except such green parts as are actually engaged in assimi-

lating carbon, under the influence of solar energies, show a tendency to assume tints other than green. This tendency would, of course, be checked by natural selection in those seeds which, like nuts, are destroyed by animals, and so endeavor to escape their notice; while it would be increased by natural selection in those seeds which, like fruits proper, derive benefit from the observation of animals, and so endeavor to attract their attention. But it is noticeable that fruits themselves are sour, green, and hard, during their unripe stage—that is to say, before the seeds are ready to be severed from the mother-plant; and that they only acquire their sweet taste, brilliant color, and soft pulp, just at the time when their mature seeds become capable of a separate existence.

Perhaps, however, the point which most clearly proves the purely functional origin of fruits is found in the immense variety of their structure, a variety far surpassing that of any other vegetable organ. It does not matter at all what portion of the seed-covering or its adjacent parts happens first to show the tendency toward succulence, sweetness, fragrance, and brilliancy. It serves the attractive purpose equally well whether it be calyx, or stalk, or skin, or receptacle. Just as, in the case of flowers, we found that the colored portion might equally well consist of stamens, petals, sepals, bracts, or spathe—so, but even more conspicuously, in the case of fruits, the attractive pulp may be formed of any organ whatsoever which exhibits the least tendency toward a pulpy habit, and an accumulation of saccharine deposits.

Thus, in the pomegranate, each separate seed is inclosed in a juicy testa or altered shell; in the nutmeg and the spindle-tree, an aril or purely gratuitous colored mass spreads gradually over the whole inner nut; in the plum and cherry, a single part, the pericarp, divides itself into two membranes, whereof the inner or protective coat is hard and stony, while the outer or attractive coat is soft, sweet, and bright-colored; in the strawberry, the receptacle, which should naturally be a mere green bed for the various seed-vessels, grows high, round, pulpy, sweet, and ruddy; in the rose, the fruit-stem expands into a scarlet berry, containing the seed-vessels within, which also happens in a slightly different manner with the apple, pear, and quince; while in the fig, a similar stem incloses the innumerable seeds belonging to a whole colony of tiny blossoms, which thus form a compound fruit, just as the daisy-head, with its mass of clustered florets, forms a composite flower. Strangest of all, the common South American cashew-tree produces its nut (which is the true fruit) at the end of a swollen, pulpy, colored stalk, and so preserves its embryo by the vicarious sacrifice of a fallacious substitute. These are only a few out of the many ways in which the selective power of animals has varied the surroundings of different seeds to serve a single ultimate purpose.

Nor is any plan too extravagant for adoption by some aberrant species. What seed-organ could seem less adapted for the attraction

of animals than a cone like that of pines and fir-trees? Yet even this hard, scaly covering has been modified, in the course of ages, so as to form a fruit. In the cypress, with its soft young cones, we can see dimly the first step in the process; in the juniper, the cone has become quite succulent and berry-like; and finally, in the red fruit of the yew, all resemblance to the original type is entirely overlaid by its acquired traits.

Equally significant is the fact that closely-allied species often choose totally different means for attracting or escaping observation. Thus, within the limits of the rose tribe itself we get such remarkable variations as the strawberry, where the receptacle forms the fruit; the apple, which depends on the peduncle, or swollen stalk, for its allurement; the raspberry, where each seed-vessel of the compound group has a juicy coating of its own, and so forth: while, on the other hand, the potentilla has no fruit at all, in the popular sense of the word; and the almond actually diverges so far from the ordinary habits of the tribe as to adopt the protective tactics of a nut. Similarly, in the palm tribe, while most species fortify themselves against monkeys by shells of extravagant hardness, as we see in the vegetable ivory, and the solid coquilla-nuts from which door-handles are manufactured, a few kinds, like the date and the doom-palm, trust rather to the softness and sweetness of their pulp, as aids to dispersion. The truth which we learn from these diverse cases may be shortly summed up thus: Whatever peculiarities tend to preserve the life of a species, in whatever opposite ways, equally aid it in the struggle for life, and may be indifferently produced in the most closely-related types.

And now let us glance for a moment—less fully than the subject demands, for this long exposition has run away with our space—at the reactive effects of fruit upon the animal eye. We took it for granted above that birds and mammals could discriminate between the red or yellow berry and the green foliage in whose midst it grows. Indeed, were other proof wanting, we should be justified in concluding that animals generally are possessed of a sense for the discrimination of color, from the mere fact that all those fruits and flowers which depend for their dispersion or fertilization upon animal agency are brightly tinted, while all those which depend upon the wind, or other insentient energies, are green or dull-brown in hue. But many actual observations, too numerous to be detailed here, also show us, beyond the possibility of error, that the higher animals do, as a matter of fact, possess a sense of color, differing in no important particular from that of civilized man.

Whether this sense was developed, however, by the constant search for berries and insects, or whether it was derived from a still earlier ancestry, it would be very difficult to decide. It is possible that, as we saw reason to believe in the case of the flowers and the insect vision, the colors of fruits and the color-sense of birds and mammals may

have gone on developing side by side; each plant surviving in proportion as its seeds grew more and more distinctive, and each animal, in turn, standing a better chance of food in proportion as its discrimination of such seeds grew more and more acute. But as there are excellent reasons for crediting fishes and reptiles also with a high faculty for the perception of color, it may be safer to conclude that the sense was inherited by birds and mammals from our common vertebrate progenitors, being only quickened and intensified by the reactive influence of fruits.

Yet it must be remembered that the earliest fruit-eaters, though they might find the scarlet, crimson, or purple coats of their food an aid to discrimination in the primeval forests, would not necessarily derive any pleasure from the stimulation thus afforded That pleasure has been slowly begotten in all frugivorous races by the constant use of these particular nerves in the search for food, which has at last produced in them a calibre and a sensitiveness answering pleasurably to the appropriate stimulation. Just as the peach, which a dog would reject, has become delicious to our sense of taste; just as the pineapple, at which he would sniff unconcernedly, has become exquisite to our sense of smell—so the pure tints of the plum, the orange, the mango, and the pomegranate, which he would disregard, have become lovely to our sense of color. And, further still, just as we transfer the tastes formed in the first two cases to the sweetmeats of the East, or to the violets, hyacinths, and heliotropes of our gardens, so do we transfer the taste formed in the third case to our gorgeous peonies, roses, dahlias, crocuses, tiger-lilies, and chrysanthemums; to our silks, satins, damasks, and textile fabrics generally; to our vases, our mosaics, our painted windows, our frescoed walls, our Academies, our Louvres, and our Vaticans. Even as we put sugar and spices into insipid dishes to gratify the gustatory nerves, whose sensibility was originally developed by the savor of tropical fruits, so do we put red, blue, and purple, into our pottery, our decoration, and our painting, to gratify the visual nerves, whose sensibility was originally developed by the rich tint of grapes and strawberries, star-apples and oranges.

And here again, as in the case of flowers, the feeling once aroused has found for itself new objects in the voluntary selection of beautiful mates—that is to say, of mates whose coloring gratified the rising delight in pure tints. The taste formed upon blossoms produced, by its reaction, crimson butterflies and burnished beetles, the sun-birds of the East, and the humming-birds of the West. So, too, the taste formed upon fruits produced, by a like reaction, parrots, cockatoos, toucans, birds-of-paradise, nutmeg-pigeons, and a thousand other tropical creatures of exquisite plumage and delicate form. As we mount up through the mammalian series, we scarcely come upon any hues brighter than dull-brown or tawny-yellow among the marsupials, the carnivores, the ruminants, or the thick-skinned beasts; but when we arrive at the

seed-eating classes, such as the rodents, the bats, and the quadrumana, we find a profusion of color in many squirrels, flying-foxes, and monkeys; while Mr. Darwin does not hesitate in attributing to the same selective action the rosy cheeks, pearly teeth, blue eyes, and golden hair, of the human species.

Nor is it only in the choice of mates that the nascent taste for color displays itself. Even below the limits of humanity bright-hued objects afford a passing pleasure to more than one æsthetically-endowed species. Monkeys love to pull crimson flowers in pieces, dart in pursuit of brilliant tropical birds, and are attracted by the sight of red or yellow rags. Those queer little creatures, the bower-birds, carry the same feeling a step further by collecting fragments of brilliantly-colored objects to decorate their gaudy meeting-places. But, when we reach the race of man, we find the love of color producing far more conspicuous secondary results. The savage daubs his body with red or blue paint, and plants his garden with the scarlet hibiscus or the purple bougainvillia. Soon, with the rise of pottery and cloth-making, he learns the use of pigments and the art of dyeing. Next, painting proper follows, with all the decorative appliances of Egypt, India, China, and Japan, until at last our whole life comes to be passed in the midst of clothing and furniture, wall-papers and carpets, books and ornaments, vases and tiles, statuettes and pictures, every one of which has been specially prepared with dyes or pigments, to gratify the feeling originally derived from the contemplation of woodland berries by prehistoric man, or his frugivorous ancestors. And all these varied objects of civilized life may be traced back directly to the reaction of colored fruits upon the structure of the mammalian eye.

What a splendid and a noble prospect for humanity in its future evolutions may we not find in this thought that, from the coarse animal pleasure of beholding food, mankind has already developed, through delicate gradations, our modern disinterested love for the glories of sunset and the melting shades of ocean, for the gorgeous pageantry of summer flowers, and the dying beauty of autumn leaves, for the exquisite harmony which reposes on the canvas of Titian, and the golden haze which glimmers over the dreamy visions of Turner! If man, base as he yet is, can nevertheless rise to-day in his highest moments so far above his sensuous self, what may he not hope to achieve hereafter, under the hallowing influence of those chaster and purer aspirations which are welling up within him even now toward the perfect day!—*Cornhill Magazine.*

SKETCH OF PROFESSOR O. C. MARSH.

By G. B. GRINNELL.

AMONG the younger workers in science in America, no name stands higher than that of Prof. O. C. Marsh. Enthusiastic, energetic, and capable of an unlimited amount of work, he has already contributed more than any one else to our knowledge of the ancient life of this continent. Many of his discoveries have proved of the greatest interest to the student of biology, and have a direct and highly-significant bearing on some of the most important scientific problems of the day. The genealogy of the horse, brought forward by Prof. Huxley in his New York lectures as the demonstrative evidence of evolution, was worked out mainly by Prof. Marsh, and was the result of his vigorous field-work and patient study.

Prof. Othniel Charles Marsh was born in Lockport, New York, October 29, 1831, and his boyhood was spent mainly in that vicinity. As a boy he was passionately fond of field-sports, and devoted much of his time to fishing and shooting. The writer has heard him remark that he was a sportsman before he was a naturalist; and it cannot be doubted that the open-air life of his early years gave him the vigorous health he has since enjoyed, while to the habits of observation acquired in the woods and fields much of his subsequent success in science has been due. He is still a keen sportsman, and very hard to beat with rod or gun. In 1852 he entered Phillips Academy at Andover, Massachusetts, where he graduated in 1856, the valedictorian of his class. He entered Yale College the same year, and graduated with high honors in the class of 1860. The next two years were spent in the study of chemistry and mineralogy in the Sheffield Scientific School at New Haven. He then went to Europe, and spent three years in the Universities of Berlin, Heidelberg, and Breslau. While in Germany he studied zoölogy and geology under the eminent teachers Ehrenberg, Rose, Bunsen, Peters, Beyrich, and Roemer. His vacations were devoted to Alpine explorations and other work in the field, during which he made several discoveries of interest, and published accounts of them in papers read before the Geological Society of Germany. He returned to New Haven in 1866, to fill the chair of Paleontology in Yale College, a position which he now holds.

During his school-days at Andover, and throughout his college course, Prof. Marsh was a devoted student of mineralogy, and many of his vacations were spent in Nova Scotia, collecting minerals and investigating the geology of that peninsula. It was here that he discovered, while yet in college, the two celebrated vertebræ of *Eosaurus Acadianus*, which still remain unique, and are thought to have been

the first remains of reptiles found in the Palæozoic rocks of America. His studies in archæology also began in college.

To many readers, Prof. Marsh is best known in connection with his explorations in the Rocky Mountains, which he has crossed no less than eleven times on his various expeditions. His first visit to that country was a short excursion in 1868, which produced results of no little interest. From an alkaline lake in Wyoming he then obtained live specimens of larval Siredons, the remarkable change in which, occurring, under his own eye, after his return, called forth the paper "On the Metamorphosis of *Siredon* into *Amblystoma*." On this trip, too, a number of interesting Tertiary fossils were obtained from a well at Antelope Station, Nebraska, in the bed of an ancient lake, and at several other localities. The discoveries thus made indicated to Prof. Marsh the importance of this previously-unknown field, and he made preparations to undertake its systematic exploration. During the years immediately following his return from Europe, he had studied with much care the Cretaceous and Tertiary fauna of New Jersey; but it now became apparent to him that the fossil resources of these deposits were of much less importance than those of the West. In June, 1870, the first of the Yale Scientific Expeditions was organized and took the field, returning after an absence of five months, richly laden with fossil treasures. Over one hundred species of extinct vertebrates, new to science, were discovered on this trip. Most of these were from two Tertiary lake-basins before unknown. During the four years which followed, Prof. Marsh led other expeditions, which were scarcely less successful than the first, and the vertebrate fossils thus collected soon came to be reckoned by tons, instead of by hundreds or thousands of specimens. These various expeditions were attended with much danger and hardship, as the regions explored were often infested with hostile Indians, and explorations could be carried on only under the protection of a strong escort of Government troops. Prof. Marsh's early experience as a sportsman was also of great advantage, as the fact that he was the quickest and best shot in the expedition was soon acknowledged, and commanded respect from the soldiers and rough mountaineers who accompanied him. The expenditure of time which the leadership of these expeditions involved was, however, so great, that recently parties of trained collectors have been sent out, who pack the fossils on the ground and ship them to the Peabody Museum of Yale College, where they are examined by Prof. Marsh and his assistants. The expenses incurred in these various explorations have been great, and were mainly borne by Prof. Marsh, who has already contributed more than $100,000 to this work.

Among the most interesting of Prof. Marsh's recent discoveries are, a new mammal (*Dryolestes*); a new order of Reptilia (*Stegosauria*), and many new and gigantic Dinosaurs, all from the Jurassic of the Rocky Mountains, and the first found in this formation in this country.

From the Cretaceous of Kansas he has obtained the first American *Pterodactyles*, including a new order (*Pteranodontia*), a new sub-class of birds with teeth (*Odontornithes*), including two new orders, the *Odontolcæ* and *Odontotormæ;* and many new Mosasauroid reptiles. In the anatomy of the latter group he has made a number of interesting discoveries which have been of great value in determining its relationship. From the Eocene Tertiary of the Rocky Mountains, he has brought to light the first monkeys, bats, and marsupials, found in this country; two new orders of mammals, the *Tillodontia*, which seem to be related to the Carnivores, Ungulates, and Rodents; and the *Dinocerata*, which were huge Ungulates, elephantine in bulk, bearing on their skulls two or more pairs of horn cores. From the same Eocene come the two earliest equines, *Eohippus* and *Orohippus*, and a host of other strange forms, all of them widely different from anything now living.

In the Miocene lake-basins of the West, Prof. Marsh has found numerous other forms, many of them apparently descendants of their predecessors in the Eocene, while others seem to stand alone. In the Miocene of the Plains occur the huge *Brontotheridæ*, a new family of Ungulates, first defined by Prof. Marsh. In size they equaled the *Dinocerata* of the Eocene, and like them their skulls were armed with horns. The same formation has also yielded to this explorer the first Miocene monkey found in America, while from the Oregon lake of this age he has described the oldest known Edentates. The new fossils obtained from the Pliocene lake-basins of the Plains and of Oregon are not less numerous than those from the earlier ones, but they are of less interest to the general reader. The remains of these ancient creatures, preserved in the Museum of Yale College, present a series which, for its interest and value to the biologist, is not surpassed by any collection in the world. Not less than four hundred new species of fossil animals have been collected by Prof. Marsh, and their remains are all at present in New Haven.

Prof. Marsh is President of the American Association for the Advancement of Science, and will preside at the St. Louis meeting this year; and, as retiring president, will deliver his address in 1879. At the meeting of the National Academy of Sciences in Washington, in April last, he was elected vice-president of that body, and, by the death of Prof. Henry, he has become its presiding officer. He is a member of several scientific societies in Europe, and has recently received from the Geological Society of London the Bigsby medal for his important discoveries in paleontology.

Prof. Marsh is a nephew of the late George Peabody, Esq., of London, and the most important gifts to science by this philanthropist are due to his influence. The Peabody Museum of Natural History, at New Haven, the Peabody Museum of Archæology and Ethnology, at Cambridge, as well as the Peabody Academy of Science, in Salem, Massachusetts, are largely the results of his advice and carefully-considered

plans. He has followed his uncle's example in princely gifts to science, and, thus far, likewise, we may add, in remaining a bachelor.

Prof. Marsh is a firm believer in evolution, and enjoys the personal acquaintance and friendship of Darwin, Huxley, Wallace, Spencer, and other prominent advocates of this doctrine. He is at present in England with his scientific friends, but will return in time for the St. Louis meeting of the Association for the Advancement of Science.

Aside from his scientific reputation, Prof. Marsh became well known to the general public, a short time since, through his contest with Secretary Delano and the Interior Department. It will be remembered that while Prof. Marsh was on his perilous expedition to the "Bad-Lands," near the Black Hills, in the winter of 1874, he was twice driven back by the Sioux Indians, who supposed him to be in search of gold rather than bones. In endeavoring to propitiate the savages, he held various councils with Red Cloud and the other principal chiefs, and at last gained permission to proceed with his party only by promising Red Cloud to take his complaints and samples of his rations to the Great Father at Washington. The fulfillment of this promise, together with an exposure of the frauds which he had seen practised upon the Indians,[1] led to a sharp fight with Secretary Delano and the Indian ring. Secretary Delano began by calling the professor "*a Mr. Marsh*," and ended by retiring to private life and political death in Ohio. The scalps of several lesser officials and contractors were taken by the professor in the same fight, and subsequent events have more than substantiated all of the charges he made. This is perhaps the only instance in which a private citizen has successfully fought a department of the Government in his efforts to expose wrong-doing. Red Cloud has since sent the professor an elegant pipe and tobacco-pouch, as a token of his gratitude, and with them the complimentary message that "the Bone-hunting Chief," as he calls the professor, "was the only white man he had seen who kept his promises."

Prof. Marsh's scientific publications, which began while he was a student, number more than one hundred, and are mostly papers in scientific journals. One of the most important of these publications is his address as Vice-President of the American Association for the Advancement of Science, delivered in August, 1877, at Nashville, Tennessee, and published in THE POPULAR SCIENCE MONTHLY for March and April, 1878. He is now engaged in the preparation of a series of monographs, with full illustrations, of his discoveries, which will be published under Government auspices. The first volume, upon the "Odontornithes, or Birds with Teeth," illustrated with forty quarto plates, is now in press, and will soon be published.

Among the more noteworthy of Prof. Marsh's scientific papers are the following:

[1] A statement of affairs at the Red Cloud Agency, made to the President of the United States, Yale College, July, 1875.

The Gold of Nova Scotia (*American Journal of Science* (2), vol. xxxii., pp. 395–400, November, 1861).

Description of the Remains of a New Enaliosaurian (*Eosaurus Acadianus*), from the Coal Formation of Nova Scotia (*American Journal of Science* (2), vol. xxxiv., pp. 1–16, November, 1862).

Catalogue of Mineral Localities in New Brunswick, Nova Scotia, and Newfoundland (*American Journal of Science* (2), vol. xxxv., pp. 210–218, March, 1863).

Description of an Ancient Sepulchral Mound near Newark, Ohio (*American Journal of Science* (2), vol. xlii., pp. 1–11, July, 1866).

Contributions to the Mineralogy of Nova Scotia (*American Journal of Science* (2), vol. xliv., pp. 362–367, November, 1867).

Observations on the Metamorphosis of Siredon into Amblystoma (*American Journal of Science* (2), vol. xlvi., pp. 364–374, November, 1868).

Notice of some New Mosasauroid Reptiles from the Greensand of New Jersey (*American Journal of Science* (2), vol. xlviii., pp. 392–397, November, 1869).

Notice of some Fossil Birds from the Cretaceous and Tertiary Formations of the United States (*American Journal of Science* (2), vol. xlix., pp. 205–217, March, 1870).

On the Geology of the Eastern Uintah Mountains (*American Journal of Science* (3), vol. i., pp. 191–198, March, 1871).

Description of some New Fossil Serpents from the Tertiary Deposits of Wyoming (*American Journal of Science* (3), vol. i., pp. 322–329, May, 1871).

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Note on a New and Gigantic Species of Pterodactyle (*American Journal of Science* (3), vol. i., p. 472, June, 1871).

Notice of some New Fossil Mammals from the Tertiary Formation (*American Journal of Science* (3), vol. ii., pp. 35–44, July, 1871).

Notice of some New Fossil Mammals and Birds from the Tertiary Formation of the West (*American Journal of Science* (3), vol. ii., pp. 120–127, August, 1871).

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Preliminary Description of New Tertiary Mammals; Part I. (*American Journal of Science* (3), vol. iv., pp. 122–128, August, 1872).

Preliminary Description of New Tertiary Reptiles; Part I. (*American Journal of Science* (3), vol. iv., pp. 299–304, October, 1872). Part II. (*American Journal of Science* (3), vol. iv., pp. 305–309, October, 1872).

Notice of some New Tertiary and Post-Tertiary Birds (*American Journal of Science* (3), vol. iv., pp. 256–262, October, 1872).

Notice of some Remarkable Fossil Mammals (*American Journal of Science* (3) vol. iv., pp. 343, 344, October, 1872).

Notice of a New and Remarkable Fossil Bird (*American Journal of Science* (3), vol. iv., p. 344, October, 1872).

Discovery of Fossil Quadrumana in the Eocene of Wyoming (*American Journal of Science* (3), vol. iv., pp. 405, 406, November, 1872).

On the Gigantic Fossil Mammals of the Order Dinocerata (*American Journal of Science* (3), vol. v., pp. 117–122, February, 1873).

On a New Sub-Class of Fossil Birds (Odontornithes) (*American Journal of Science* (3), vol. v., pp. 161, 162, February, 1873).

On the Structure and Affinities of the Brontotheridæ (*American Journal of Science* (3), vol. vii., pp. 81–86, January, 1874).

Notice of New Equine Mammals from the Tertiary Formation (*American Journal of Science* (3), vol. vii., pp. 247–258, March, 1874).

New Order of Eocene Mammals (*American Journal of Science* (3), vol. ix., p. 221, March, 1875).

On the Odontornithes, or Birds with Teeth (*American Journal of Science* (3), vol. x., pp. 403–408, November, 1875).

Principal Characters of the Dinocerata (*American Journal of Science* (3), vol. xi., pp. 163–168, February, 1876).

Principal Characters of the Tillodontia (*American Journal of Science* (3), vol. xi., pp. 249–251, March, 1876).

Principal Characters of the Brontotheridæ (*American Journal of Science* (3), vol. xi., pp. 335–340, April, 1876).

On a New Sub-Order of Pterosauria (*American Journal of Science* (3), vol. xi., pp. 507–509, June, 1876).

Recent Discoveries of Extinct Animals (*American Journal of Science* (3), vol. xii., pp. 59–61, July, 1876).

Notice of New Tertiary Mammals; Part V. (*American Journal of Science* (3), vol. xii., pp. 401–404, November, 1876).

Principal Characters of American Pterodactyles (*American Journal of Science* (3), vol. xii., pp. 479, 480, December, 1876).

Notice of a New and Gigantic Dinosaur (*American Journal of Science* (3), vol. xiv., pp. 87, 88, July, 1877).

Principal Characters of the Coryphodontidæ (*American Journal of Science* (3), vol. xiv., pp. 81–85, July, 1877).

Characters of the Odontornithes, with Notice of a New Allied Genus (*American Journal of Science* (3), vol. xiv., pp. 85–87, July, 1877).

Address on Introduction and Succession of Vertebrate Life in America (*American Journal of Science* (3), vol. xiv., pp. 338–378, November, 1877).

A New Order of Extinct Reptilia (*Stegosauria*) from the Jurassic of the Rocky Mountains (*American Journal of Science* (3), vol. xiv., pp. 513, 514, December, 1877).

New Species of Ceratodus, from the Jurassic (*American Journal of Science* (3), vol. xv., p. 76, January, 1878).

Notice of New Dinosaurian Reptiles (*American Journal of Science* (3), vol. xv., pp. 241–244, March, 1878).

Notice of New Fossil Reptiles (*American Journal of Science* (3), vol. xv., pp. 409–411, May, 1878).

Fossil Mammal from the Jurassic of the Rocky Mountains (*American Journal of Science* (3), vol. xv., p. 459, June, 1878).

Other scientific papers of interest by Prof. Marsh will be found in the same journal, as well as in the *Zeitschrift* of the Geological Society of Germany; *American Naturalist;* "Proceedings of the Philadelphia Academy of Natural Sciences;" "Proceedings of the American Philosophical Society; "Proceedings of the American Association for the Advancement of Science;" and in other periodicals.

EDITOR'S TABLE.

THE ENGLISH REPORT ON INTERNATIONAL COPYRIGHT.

THE report of the English commission on the general subject of copyright is now complete and before the public. It shows that there has been a searching investigation into the existing condition and working of copyright-laws in that country, with an honest view to such amendments as are necessary to more thorough protection of the right to literary property. The report is able and exhaustive, and recommends parliamentary measures which, if carried out, will be of great advantage to authors, and will be an honor to England. The commissioners found the subject encompassed with serious and perplexing difficulties, but they did not make these the occasion of shrinking from the duty that had been assigned to them. If any American wishes to preserve a decent self-respect, we advise him not to pass from the reading of the English copyright report to the report of the United States Senate upon the same subject, made in 1873, by Mr. Morrill, of Maine. The contrast between the two documents is remarkable. The English report is grave and formidable, and shows that there has been long and earnest work over a question that is felt to be of great national importance; the American report is a miserable tract of half a dozen pages, evincing by its meagreness the utter indifference of those who drew it up to the subject which they had been appointed to consider. The English report recognizes extensive defects in the legislation of that country upon the question, and recommends bold changes in it to secure a better state of things; the American report sees nothing wrong that it is desirable to amend, and recommends Congress to take no action in the matter. It treats the subject from the low and selfish point of view of the American political demagogue, enters with a relish into the sordid squabbles of book-manufacturers, and pays not the slightest attention to the important principles that should be recognized as at the basis of a just and enlightened policy of international copyright. The English report, on the contrary, treats the subject with dignity and seriousness, bringing out clearly the great principles that should control it, and taking high and impregnable moral ground in regard to the duty of the English Parliament in legislating with reference to it. It is a question of international ethics, and England has shot a long way forward by adopting the Christian standard of conduct in this relation, and saying we are prepared to do as we would be done by. The high-water mark of international morality hitherto reached has been to do as you *are* done by, to reciprocate, to concede benefits if benefits are granted, and to deny them if they are denied. England takes the lead in affirming that the thing which is right, just, and equitable, must be done, whether other nations reciprocate or not. She took an important step in this direction in entering upon the policy of free trade, and now proposes to carry it out in her international treatment of literary property and the rights of authors. The commission recommends to Parliament to grant copyrights to American authors whether the United States will do the same thing for English authors or not. They say: "It has been suggested to us that this country would be justified in taking steps of a retaliatory character, with

a view of enforcing, incidentally, [illegible] protection from the United States which we accord to them. This might be done by withdrawing from the Americans the privilege of copyright on first publication in this country. We have, however, come to the conclusion that it is advisable that our law should be based on correct principles, irrespective of the opinions or policy of other nations. We admit the propriety of protecting copyright, and it appears to us that the principle of copyright, if admitted, is one of universal application. We, therefore, recommend that this country should pursue the policy of recognizing the author's rights, irrespective of nationality."

On a subject which presents so much that is conflicting and unsettled, it is not to be supposed that there would be complete unanimity of opinion among the fifteen members of this commission, who were chosen because they are men of intelligence, and capable of forming their own views. The subject, besides, was one of great extent and complication of rival interests, involving the policy to be pursued regarding home and foreign copyrights, abridgments of books, musical compositions, dramatization of novels, lectures, newspapers, paintings, photographs, translations, registrations, forfeitures, infringements, and scores of other matters hitherto left to a chaotic system of legislation. But, considering the task they had before them, the commissioners have come to substantial agreement as to the measures recommended. There were two or three wrong-headed and crotchety men, who made dissenting reports on various points, although concurring in the main practical results. Chief among these eccentric dissentients was Sir Louis Mallet; he could not agree with his coadjutors, and with some of the leading gentlemen who testified before them, as to the ground of rights in literary property. Many ingenious and fanciful arguments have been made to prove that men have no right to the property they create by brain-labor, or have only such a qualified right to it that to appropriate it without consent is not stealing. What a man earns by his hands, and by capital invested in tools and machinery, they admit he has a right to against the world; but what he earns by laborious thinking, and by capital invested in education, may be taken from him by anybody who wants it. Many funny reasons, as we have said, have been offered for allowing those who can make anything by it for themselves to plunder authors of the products of their toil, but Sir Louis Mallet has the honor of contributing the last curious pretext for this sort of robbery. He says: "The right conferred by a copyright-law derives its chief value from the discovery of the art of printing; and there appears no reason for giving to authors any larger share in the value of a mechanical invention, to which they have contributed nothing, than to any other member of the community." But, if authors are not to be permitted to hold their property because the discovery of the art of printing has contributed to its value, what right has anybody to hold any property that is the result of an invention or discovery to which he has not contributed? The doctrine would make sad havoc of the rights of capitalists and laborers in all countries, whose earnings and accumulations are due to the use of steam-engines, telegraphs, spinning-machinery, and a thousand other devices to which they have never contributed.

Sir Louis Mallet coincides in the practical recommendations of the report, although not agreeing with the grounds upon which they are made. Yet he exhibited a good deal of ingenious perverseness in embarrassing the inquiry. This was well illustrated by the case he undertook to make out against the necessity of international copyright by the success of the "International Scientific Series," where foreign authors are paid without the compulsion of an international copyright-

law. His case, in a word, is this: By a satisfactory arrangement contributors to the "International Scientific Series" are liberally paid by the English publisher, and then fairly paid again by the American publisher—what more is wanted? The answer, of course, is very simple: There is wanted legal protection to the property. The American publishers concede that there is a property-value in the books they reissue, for which they are willing to pay under a voluntary contract; but how does that proceeding absolve the United States Government from the duty of protecting that property as it protects other property? Reasonable men will see that the convention of publishers in different countries, to carry out such a project, is but a weighty testimony to the just claims of authors which it is the duty and office of government to sustain and enforce by the proper legislation. It is the one great duty of government to protect the rights of its citizens, and prominent among these is the right of property. All civilized countries recognize the right of property in books, and there have been attempts to make this recognition international, that is, to induce nations to extend their morality beyond their geographical borders. In the absence of any such arrangement, a few parties agree that they will voluntarily recognize the rights of intellectual property, and the very doing of this is to be made a new excuse for neglecting to enforce the fundamental obligations of justice.

COOKERY AND EDUCATION.

It was a suggestive remark of Count Rumford that "the number of inhabitants who may be supported in any country upon its internal produce depends about as much upon the state of the *art of cookery* as upon that of agriculture; but, if cookery be of so much importance, it ought certainly to be studied with the greatest care. Cookery and agriculture are arts of civilized nations; savages understand neither of them."

There is a great deal of important truth wrapped up in this passage, of vital interest to society in general and to individual welfare, but which it has taken a hundred years to appreciate so fully that any considerable number of people can begin to coöperate in reducing it to practice. But, if what Rumford said is true, if the scale of population as well as the comfort and health of the people depends to such a degree upon the art of cookery, what are all the issues of politics over which men are fighting with such desperation in comparison with the systematic improvement of the culinary art? How greatly the public weal is dependent upon the condition of agriculture begins now to be widely understood, and since the time of Rumford great progress has been made in its scientific study through the establishment of special schools and colleges for the purpose. Agricultural education is now a recognized branch of popular culture which is destined to be greatly developed and extended in the future. The next great step must be to do the same thing for the art of cookery; and the friends of genuine social improvement may congratulate themselves that the progress of education is beginning to take effect upon this important department of domestic life. Cooking-schools are springing up in many places in this country and in England, and the English are taking the lead in organizing them as a part of their national and common school system.

Of the importance, the imperative necessity of this movement, there cannot be the slightest question. Our kitchens, as is perfectly notorious, are the fortified intrenchments of ignorance, prejudice, irrational habits, rule-of-thumb, and mental vacuity, and the consequence is that the Americans are liable to the reproach of suffering beyond any other people from wasteful,

unpalatable, unhealthful and monotonous cookery. Considering our resources, and the vaunted education and intelligence of American women, this reproach is just. Our kitchens are, in fact, almost abandoned to the control of low Irish, stupid negroes, and raw servile menials that pour in upon us from various foreign countries. And, what is worse, there is a general acquiescence in this state of things, as if it were something fated, and relief from it hopeless and impossible. We profess to believe in the potency of education, and are applying it to all other interests and industries excepting only that fundamental art of the preparation and use of food to sustain life which involves more of economy, enjoyment, health, spirits, and the power of effective labor, than any other subject that is formally studied in the schools. We abound in female seminaries and female colleges, and high-schools, and normal schools, supported by burdensome taxes, in which everything under heaven is studied except that practical art which is a daily and vital necessity in all the households of the land.

Acquiescence in this state of things as something permanent and irremediable is no longer possible. If, as Rumford says, cookery is an art of civilized nations, it must improve with the advance of civilization. It is undoubtedly the most backward of all the arts, and various causes conspire to its continued neglect. But, whatever the difficulties to be overcome, the time has arrived when the advance of intelligence and the spirit of improvement must invade that last stronghold of traditional stupidity, the kitchen. Nor are the difficulties of doing this by any means so great as is commonly supposed; they will vanish as soon as the task of alleviation and amendment is earnestly undertaken. As soon as thought and cultivation are brought to bear upon the domestic operations of the kitchen, they will be elevated in the common respect, and a most formidable impediment will thus be removed. American women have been driven out of the kitchen because all its associations are degrading, and they demand education as a preparation for all those other activities to which educations leads. When the art of cookery becomes a matter of intelligent study, so that its practice will no longer be a badge of debasement and humiliation, occupation will be sought and honored in this field as elsewhere. The establishment of cooking-schools is, therefore, in the direct line of our domestic amelioration and emancipation. They are already, as we have said, established, and, considering the embarrassments of an initial movement of this kind, are in most successful operation. Though at present narrow in their scope, they will develop and widen so as to afford a training in the broader field of general household activity; but we are well content with what has been already gained. The South Kensington Cooking-School, in London, is a normal school for training teachers to go out and take charge of other schools in different parts of the country. How successful this institution has been may be inferred from the fact that it has already given us the best practical cook-book that we now have. We call attention to the notice of this work in the following pages, from which the reader will gather some interesting information as to what has been accomplished on the other side of the Atlantic in relation to this important subject, and which will afford important hints for carrying out a similar work in the United States.

SCIENCE IN RELATION TO TEACHING.

Of all the applications of science to the practical arts, there is none that can for a moment bear comparison with its application to the art of teaching. Scientific education, as currently understood, refers to something of greatly inferior importance: it means instruc-

tion in the sciences. Many of the teachers in our schools know something of these sciences, and do what they can to expound them. This, of course, is useful, but it is the lowest agency for the diffusion of science. Of the uses of science to themselves as professors of the art of teaching, or of its value in guiding the processes of education, it is not too much to say that the mass of teachers as yet know nothing. This, however, is the main and essential thing now to be imperatively demanded, and which, when attained, will do more toward the universal promotion of science than all other modes of influence combined. Scientific education is far less a question of the number of hours per week that are to be devoted to this kind of study than a question of bringing scientific knowledge to bear upon the operations of the school-room.

We took this ground decisively twenty years ago. When applied to by Mr. Greeley to write some articles for the *Tribune* on "Scientific Education," we devoted them to a statement of the ground that science requires all intelligent teachers to take in the pursuit of their profession. We illustrated and enforced the position that, to develop the mind and form the character, the starting-point of the teacher must be a knowledge of the brain and of nervous physiology, and that all teaching without this knowledge must be empirical, is certain to be faulty, and liable to be injurious. The discussion was premature. We sowed upon unprepared ground. It was objected that all beyond the bare introduction of more chemistry and physics in the schools was impracticable and fanciful; while to talk of "brain" instead of "mind" was dreaded as dangerous, and condemned as leading "straight down to materialism."

In a work published a dozen years ago, "On the Culture demanded by Modern Life," this view was reaffirmed and more fully illustrated. It was insisted that to gain definite ideas of the laws of mind so as to work the forces of education *quantitatively*, if we may so speak, for the production of permanent effects, we must recognize the law of mental limitations that is educible from cerebral physiology. In an essay treating of the philosophy of mental discipline we said:

"It no longer admits of denial or cavil that the Author of our being has seen fit to connect mind and intelligence with a nervous mechanism; in studying mental phenomena, therefore, in connection with this mechanism, we are studying them in the relation which God has established, and therefore in the only true relation. Nothing is more certain than that, in future, mind is to be considered in connection with the organism by which it is conditioned. When it is said that the brain is the organ of the mind, it is meant that in thinking, remembering, reasoning, *the brain acts*. The basis of educability, and hence of mental discipline, is to be sought in the properties of that nervous substance by which mind is manifested. When it is perceived that what we have to deal with in mental acquirement is organic processes which have a definite time-rate of activity, so that, however vigorously the cerebral currents are sustained by keeping at a thing, acquisition is not increased in the same degree; when we see that new attainments are easiest and most rapid during early life—the time of most vigorous growth of the body generally; that thinking exhausts the brain as really as working exhausts the muscles, while rest and nutrition are as much needed in one case as the other; when we see that rapidity of attainment and tenacity of memory involve the question of cerebral adhesions, and note how widely constitutions differ in these capabilities, how they depend upon blood, stock, and health, and vary with numberless conditions—we become aware how inexorably the problem of mental attainment is hedged round with limitations, and the vague notion that there are no bounds to acquisition except imperfect application disappears forever."

The general view (here illustrated in a special application) has been maintained in THE POPULAR SCIENCE MONTHLY from the outset. We have published papers from the ablest scientific men of different countries, illustrating the control of physiological and psychological principles over the objects and methods

of education. These able discussions, we are happy to say, have been increasingly appreciated; and it is gratifying to note that the view we have steadily urged for these many years begins to be widely accepted as the basis of a new departure in the progress of scientific education. A conspicuous illustration of this has recently been afforded by the course of the most influential journal in England. There has been a systematic movement in that country to get a larger share of scientific study in the lower schools; and, under the vigorous leadership of Sir John Lubbock, in the House of Commons, efforts have been made to modify school legislation so as to enforce this result. A majority has not yet been gained, but the opposition is giving way, and the end sought will undoubtedly soon be attained. Upon the last and recent defeat of Sir John Lubbock's measure, the London *Times* came out with a leading editorial on the right side, and which is chiefly remarkable for the advanced and unqualified position which it takes. We reprint this article of the *Times* in the present number of the MONTHLY, together with the comments of the editor of *Nature* upon it. How completely the writer sustains the views that we have long labored to inculcate, is well shown in the following instructive passage:

"As soon as physiologists had discovered that all the faculties of the intellect, however originating or upon whatever exercised, were functions of a material organism or brain, absolutely dependent upon its integrity for their manifestation, and upon its growth and development for their improvement, it became apparent that the true office of the teacher of the future would be to seek to learn the conditions by which the growth and the operations of the brain were controlled in order that he might be able to modify these conditions in a favorable manner. The abstraction of the 'mind' was so far set aside as to make it certain that this mind could only act through a nervous structure, and that the structure was subject to various influences for good or evil. It became known that a brain cannot arrive at healthy maturity excepting by the assistance of a sufficient supply of healthy blood; that is to say, of good food and pure air. It also became known that the power of a brain will ultimately depend very much upon the way in which it is habitually exercised, and that the practice of schools in this respect left a great deal to be desired. A large amount of costly and pretentious teaching fails dismally for no other reason than because it is not directed by any knowledge of the mode of action of the organ to which the teacher endeavors to appeal; and mental growth, in many instances, occurs in spite of teaching rather than on account of it. Education, which might once have been defined as an endeavor to expand the intellect by the introduction of mechanically compressed facts, should now be defined as an endeavor favorably to influence a vital process; and, when so regarded, its direction should manifestly fall somewhat into the hands of those by whom the nature of vital processes has been most completely studied. In other words, it becomes neither more nor less than a branch of applied physiology; and physiologists tell us with regard to it that the common processes of teaching are open to the grave objection that they constantly appeal to the lower centres of nervous function, which govern the memory of and the reaction upon sensations, rather than to those of higher ones which are the organs of ratiocination and of volition. Hence a great deal which passes for education is really a degradation of the human brain to efforts below its natural capacities. This applies especially to book-work, in which the memory of sounds in given sequences is often the sole demand of the teacher, and in which the pupil, instead of knowing the meaning of the sounds, often does not know what 'meaning' means. As soon as the sequence of the sounds is forgotten, nothing remains, and we are then confronted by a question which was once proposed in an inspectorial report: 'To what purpose in after-life is a boy taught, if the intervention of a school vacation is to be a sufficient excuse for entirely forgetting his instruction?'"

THE CLASSICS IN GERMANY.

THOSE of our readers who have perused the previous portions of Prof. Du Bois-Reymond's article on "Civilization and Science" will hardly need that we should call their attention to

the concluding part herewith published. After a survey of the progress of the human mind as illustrated in the great scientific movement of modern times, he comes to the practical question of German education, considered in relation to those extreme utilitarian tendencies of the age against which he protests. How is the Americanization of European culture to be withstood in Germany?—that is his question. The reply has been, through the liberalizing influence of classical studies. The professor acknowledges himself a devotee to these studies, and has a high opinion of their educational value; but he admits that, although prosecuted with great vigor, they have failed to produce the desired effect. "What other country can boast of imparting so thorough and so learned a classical education, and that to so large a proportion of its youth, even of the less wealthy classes?" But all this is a humiliating failure. They neither acquired a critical familiarity with Latin and Greek vocabularies, nor did they arrive at any such conception of the thought of the ancients as to see in what way we are their intellectual descendants. "Their indifference toward broad ideas and historic sequence makes it difficult for me to believe that they are permeated with the spirit of antiquity, or that they had received a sound historical training." This, it will be remembered, is the complaint everywhere—in the English universities and the American colleges: not one in ten of those who consume years in the study of classics gets any intelligent acquaintance with the subject. It is, moreover, an old and cogent objection to the usual study of Latin and Greek, both in England and in this country, that, so far from favoring a critical knowledge of English, it hinders and defeats the mastery of the mother-tongue. Prof. Du Bois-Reymond alleges that the same effect is produced in Germany. Of the graduates of the gymnasia who had drilled so long, though ineffectually, in Latin and Greek, he says, "For the most part these young people wrote in ungrammatical and inelegant German." They "did not even suspect that any one could care about purity of language and pronunciation, force of expression, brevity, or pointedness of style." The study of classical authors is again arraigned with us as obstructing the proper study of the great English classics; and Prof. Du Bois-Reymond remarks, "This neglect of the mother-tongue in the youth of the present day is accompanied by a lack of acquaintance with the German classics that is oftentimes astounding." It is again said that the classical students of English and American colleges very rarely acquire any permanent interest in these studies, so as to keep them up as a part of the mental occupation in after-life. The same complaint is made in Germany. The professor says:

"There are but few students, indeed, who in later years ever open an ancient author. So far from having any warm love for the classics, most persons regard them with indifference; not a few with aversion. They are remembered only as the instruments by means of which they were made familiar with the rules of grammar, just as the only conception they retain of universal history is that of learning by rote insignificant dates. Was it for this that these youths sat for thirty hours weekly on a school-bench till their eighteenth or twentieth year? Was it for this that they devoted most of their time to studying Greek, Latin, and history? Is this the result for the attainment of which the gymnasium remorselessly englooms the life of the German boy?"

Prof. Du Bois-Reymond therefore acknowledges a serious modification of opinion in regard to the employment of classical studies in the German schools. The gymnasia, or higher schools, have failed with their classics, and the industrial schools in which these studies are but little taught are entitled to increasing consideration. Classical studies, he

urges, should be retrenched in the gymnasia, and greater attention given to mathematics and the physical sciences. This conflict, therefore, belongs to no nation, but is as broad as the interests of science and the course of civilization itself.

Prof. William Monroe Davis, of Cleveland, Ohio, died on the 21st of July, at the age of seventy years. He was born in New Hampshire, and his ancestry on the father's side went back to the Pilgrims of the Mayflower, while on the mother's side he was closely related to the family of President Monroe. He went to Cincinnati in his boyhood, and grew up there with but a limited education. It was only when married and having children to be trained that he first began the study of science; but such was his native genius that he soon mastered a position as an original thinker and investigator in astronomy. The distinction he had won could not be better shown than by the fact that, when Prof. Mitchell abandoned science and took to the vocation of war, Mr. Davis was called to succeed him as director in the Cincinnati Observatory, a position which he filled with satisfaction and credit. His health failing five years ago, he came to Cleveland to reside with his son-in-law, Mr. A. J. Rickoff, the eminent educationist of Ohio. He constructed a very valuable telescope, the lenses of which were ground by his own hands. He published in the July number of The Popular Science Monthly a paper containing an able and profound discussion of the nebular hypothesis and the phenomena of planetary rings and satellites, the immediate occasion of the article being the recent discovery and apparently anomalous motions of the moons of Mars. Prof. Davis had worked out his own views on these recondite questions, and expected to develop them in a series of essays for the Monthly, when his work was arrested by death. It is to be hoped that his manuscript notes may have been sufficiently full to make it practicable and desirable for his friends to print them in a collected form.

LITERARY NOTICES.

Lessons in Cookery: Hand-Book of the National Training-School for Cookery (South Kensington, London). To which is added The Principles of Diet in Health and Disease, by Thomas K. Chambers, M. D. Edited by Eliza A. Youmans. New York: D. Appleton & Co. Pp. 382. Price, $1.50.

Two things closely connected are much and justly complained of in this country—the everlasting multiplication of new cookbooks and the general badness of cookery. Publications of every form and variety abound upon this subject, with no corresponding improvement in the art by which food is prepared. It would be going too far to ascribe the low state of our culinary practice to the qualities of the literature that deals with it, for in many cases cookbooks have no influence at all upon kitchen operations; but it is equally certain that the current manuals do much to perpetuate the bad methods to which they are conformed. The reason of their failure to effect much improvement is obvious enough, for our popular manuals of cookery make no provision for learning the business in the way all other arts have to be learned if they are to be successfully prosecuted. They proceed upon the false principle that a practical vocation, depending upon a knowledge of the properties of numerous substances, involving constant manipulation and the production of delicate and complicated effects, can be learned by simply reading about it. This mischievous error, however, is beginning to be recognized in various quarters, and it is seen that cookery, like all other subjects, must be studied in a rational way, in accordance with the nature of the subject. England has the honor of taking the lead in a vigorous movement to make the art of practical cookery a branch of common education. The effort has been successful in so eminent a degree that it promises to be perma-

nent and to become of immense advantage to the community. But no important step of advancement can be taken in this direction without a wide diffusion of its advantages; whatever has been gained by English experience is ours as well as theirs. One of the fruits of the establishment of the London Training-School is that we have at last got a hand-book of cookery upon the right method, and which, if used as it can be everywhere, will be certain to elevate this hitherto neglected branch of domestic economy. The claims of this work upon American households are so important, and so clearly presented by the editor in her preface to the American edition, that we cannot better serve the interested readers of the MONTHLY than by quoting the main portions of the statement:

"The present work on cookery appeared in England under the title of 'The Official Hand-Book of the National Training-School for Cookery,' and it contains the lessons on the preparation of food which were practised in that institution. It has been reprinted in this country with some slight revision, for the use of American families, because of its superior merits as a cook-book to be consulted in the ordinary way, and also because it is the plainest, simplest, and most perfect guide to *self-education in the kitchen* that has yet appeared. In this respect it represents a very marked advance in an important domestic art hitherto much neglected.

"A glance at its contents will show the ground it covers, and how fully it meets the general wants. The dishes for which it provides have been selected with an unusual degree of care and judgment. They have been chosen to meet the needs of well-to-do families, and also those of more moderate means, who must observe a strict economy. Provision is made for an ample and varied diet, and for meals of a simple and frugal character. Receipts are given for an excellent variety of soups, for cooking many kinds of fish in different ways, for the preparation of meats, poultry, game, and vegetables, and for a choice selection of entrées, soufflés, puddings, jellies, and creams. Besides the courses of a well-ordered dinner, there are directions for making rolls, biscuits, bread, and numerous dishes for breakfast and tea, together with a most valuable set of directions how to prepare food for the sick. The aim has been to meet the wants of the great mass of people who are not rich enough to abandon their kitchen to the management of professional cooks, and who must keep a careful eye to expense. But, while the costly refinements of artistic and decorative cookery are avoided, there has been a constant reference to the simple requirements of good taste in the preparation of food for the table.

"But the especial merit of this volume, and the character by which it stands alone among cook-books, is the superior method it offers of teaching the art of practical cookery. It is at this vital point that all our current cook-books break down; they make no provision for getting a knowledge of this subject in any systematic way. So much in them is vague, so much taken for granted, and so much is loose, careless, and misleading, in their receipts, that they are good for nothing to teach beginners, good for nothing as guides to successful practice, and only of use to those who already know enough to supply their deficiencies and protect themselves against their errors. In fact, the hand-book required to teach cookery effectually cannot be made by any single person in the usual manner, but it must be itself a product of such teaching.

"The present volume originated in this way, and embodies a tried and successful method of making good practical cooks. The lessons given in the following pages came from a training-kitchen for pupils of all grades, and the directions of its receipts are so minute, explicit, distinct, and complete, that they may be followed with ease by every person of common-sense who has the slightest desire to learn. They are the results of long and careful practice in teaching beginners how to cook, and have grown out of exercises often repeated with a view of making them as perfect as possible. It is commonly regarded as a good thing in a cook-book that its compiler has tested some of its receipts, and points out the troubles and failures likely to occur in early trials. But the completeness of the instructions in this work was attained through the stupidities, blunders, mistakes, questionings, and

difficulties, of hundreds of learners of all capacities, doing the work over and over again under the critical direction of intelligent, practical teachers, who were bent upon finding out the best method of doing each thing, and the best method of teaching others how to do it. Not a single item necessary to perfect the required process is omitted. The steps are separated, and given in numerical order, so as to enforce attention to one thing at a time, and the right thing at the right time, while the precautions against mistakes are so careful that even the dullest can hardly go wrong. Each receipt in the volume is not only the formula for a dish, but it is also a lesson in a practical process, so that in the preparation of every article of food something is gained toward greater proficiency in the art of cooking well.

"A few words in regard to the origin of the school in which it was produced will still further illustrate the character of this work. A vigorous movement has been made in England to elevate this branch of domestic economy by establishing schools for training pupils in the art of cookery. These schools have grown immediately out of the need of greater general economy among the working-classes, as it was seen that the high prices of provisions were seriously aggravated by not knowing how to make the most of them in their kitchen preparation. The attention of the managers of the South Kensington Museum of Arts in West London was several years ago drawn to the subject; and, feeling that something required to be done, they established public lectures on the preparation of food, with platform demonstrations of various culinary operations. But it was quickly found that mere exposition and illustration, though not without use, were wholly inadequate to the object in view; because a cooking school, to be thorough, must provide for practice. Lecturing, and explaining to pupils, and barely showing them how things are done, are sure to fail, because cookery, like music, can only be learned by actually doing it. As well undertake to teach the piano by talking and exhibiting its capabilities as to teach a person how to make a dish properly by only listening and looking on. Provision had therefore to be made for forming classes to do themselves what they at first only saw others do.

"But this task was by no means an easy one. There were no preëxisting plans to follow; qualified teachers and suitable textbooks were wanting; it was an expensive form of education; the public thought it a doubtful innovation; and educational authorities discouraged it. But the parties interested decided that the time had come for a systematic and persistent effort. They felt their way cautiously, and in 1874 organized classes for graded courses of practice. The object was to give women the best possible instruction in practical cookery, and for this purpose the school was open to all. But, to make its work most largely useful, it was constituted as a normal school for training teachers to go out and establish other cooking-schools in different parts of the country. This has been since done with the most encouraging success, so that there are already a large number of cooking-schools in England connected with the national or common school system.

"As no cook-book to be found was worth anything to aid the practical instruction proposed, the teachers had to take this matter in hand at the outset. They began by drawing up a careful set of directions to be followed by the learners in doing their work. For each lesson in all the grades each pupil was furnished with a printed sheet of these directions, stating the ingredients of each dish to be prepared, the quantities and separate cost of these ingredients, what was to be done first, what next, and so on through the whole series of operations, nothing being assumed as known, and all the minute steps being indicated in the order that was found best. These guides were necessarily imperfect at first, and were subject to constant revision and extension as experience suggested corrections; in fact, they embodied the progress of the school in the successful attainment of its object. At each new printing the improvements that had been made were incorporated, and only after years of trial were these guides to practice at length combined and issued in a book-form. The lessons or receipts of this volume were all slowly elaborated in this painstaking manner, and the mode of working proved perfectly success-

ful with the pupils. It was easy and pleasant, yet careful and thorough, and secured a rapid and gratifying proficiency.

"In saying that the South Kensington Cooking-School has been successful, I speak from direct knowledge of it. I was a pupil there for several weeks, and carefully observed its operations. The classes showed the most extraordinary mental and social diversity. There were cultivated ladies, the daughters of country gentlemen, old housekeepers, servants, cooks, and colored girls from South Africa, together with a large proportion of intelligent young women who were preparing to become teachers. They worked together with a harmony and good feeling that, I confess, somewhat surprised me, but they were all closely occupied and thoroughly interested in a common object. There were teachers to provide materials, to plan the daily work, to direct operations, and to be consulted when necessary; but the admirable method adopted left each learner to go through her task with but a small amount of assistance. Indeed, the completeness of the directions in hand seemed to assure the success of every pupil from the start. There was, of course, a difference in dexterity, and in facility of work previously acquired; but raw beginners went on so well that they were astonished at what they found themselves able to do.

"American ladies, when looking over these lessons, are apt to smile at their extreme simplicity and triviality, but it must be remembered that the difference between good and bad cookery is very much a matter of attention to trifles. Slight mistakes, small omissions, little things done at the wrong time, spoil dishes. The excellence of these lessons consists in their faithfulness in regard to minutiæ, and the habits they enforce of attention to trifling particulars. They make no claim to literary merit. The receipts are homely, direct, and meant only to be easily and distinctly understood. They are full of repetitions, because processes are constantly repeated, and it was necessary that the directions in each receipt should be full and complete. They are not enticing reading, because they were made to work by. The book, in fact, belongs in the kitchen where cookery is done; and it is now republished because its success there has been demonstrated. Many hundred persons totally ignorant of the subject have become efficient and capable cooks by pursuing the mode of practice here adopted—by going through these lessons—and the same results can be obtained by pursuing the same method anywhere. American housekeepers who have any real interest in home improvement, and are willing to take a little pains to instruct their daughters or their servants in the art of cooking well, will find the volume an adequate and invaluable help toward the attainment of this object. It will prove a useful text-book in the cooking-schools that are springing up in this country, and classes could be advantageously formed in it for kitchen practice in every female seminary in the land."

Appended to the volume is an admirable essay on "The Principles of Diet in Health and Disease," by Dr. Thomas K. Chambers, one of the highest living authorities upon that subject. This is a most valuable addition to the work. As food is prepared in order to be eaten, as the subject of cookery is therefore in close relations with that of diet, and commonly receives too little attention on the part of housekeepers, it was an excellent idea to furnish an authoritative summary of the facts and rules of the most recent dietetical science. Good cookery and rational diet are equal conditions of healthful enjoyment.

ANNUAL RECORD OF SCIENCE AND INDUSTRY, FOR 1877. By S. F. BAIRD. New York: Harper & Brothers. Pp. 494. Price, $2.

THE "Record" for 1877 is considerably less voluminous than its predecessors, and the reduction in size has been effected by summarily omitting one of the two main divisions of the work, namely, that containing abstracts of notable scientific papers. In truth, it would be simply impossible to compress within the limits of an ordinary volume an intelligible synopsis of the important scientific papers annually contributed to the proceedings of learned societies and the periodical press. Hence, we cannot but approve the action of Prof. Baird in omitting that feature of the "An-

nual Record." By so doing, he is enabled to give more space and fuller treatment to the "Summary of Scientific Progress," and the result is a remarkably satisfactory review of the scientific work of the year in the various departments of research. Each particular science, and, in some instances, particular departments of a science, are treated by writers eminent in their respective specialties.

THE ETHICS OF POSITIVISM: A CRITICAL STUDY. By GIACOMO BARZELLOTTI, Professor of Philosophy at the Liceo Dante, Florence. New York: Charles P. Somerby. Pp. 327. Price, $2.

THIS book, the first edition of which appeared in Florence a few years ago, and is now translated into English and printed in this country with a new introduction by the author, is a study of those more recent aspects of philosophy which have culminated in the British school of psychologists. It seems to have been written with a principal view of instructing the Italians in regard to the great modern movements of thought that are going on most actively outside the limits of that country. But the writer's object is by no means purely expository of current thought: he dips into controversy with opinions of his own, and avows his aim to be to defend "the principles of morality against the attacks of an empirical utilitarianism." The appellation of positivism, which the author connects with his discussion, he informs us has been criticised by leading authorities as inexact, and we think the objection was certainly well taken. At any rate, the propriety of the term, as designating the English school of thinkers with which he is chiefly dealing, has been so strenuously contested as misleading by prominent members of that school, that it seems somewhat assuming in Prof. Barzellotti to persist in this questionable or disputed application of the word in the title of his book.

The work is similar in scope to Masson's "Recent British Philosophy," and its topics are discussed in an excellent spirit and in an intelligent and instructive manner; but it will be more valued as a delineation of a system of ideas than for any contribution it offers toward their further development. We notice that Prof. Barzellotti differs very widely from President Porter in his estimate of the philosophical position and influence of Herbert Spencer. For, while to the President of Yale College Spencer is little better than a pretender and a verbal trickster, whose illusive reputation is destined to vanish so speedily that the world will wonder how the delusion lasted so long, the Italian professor, on the other hand, accords to him a regnant place as the commanding mind of the most vigorous and powerful philosophical school of the present age. He says, "Modern psychological inquiry reaches its highest degree of development in Herbert Spencer." He closes an elaborate account of the doctrines and methods of this thinker as follows:

"Such is in outline the psychology of Herbert Spencer. The idea that rules it is that of a harmony of things which extends by degrees from one form of life to another and culminates in mind. It is not an original idea, but it acquires particular aspects when thus treated according to the positive method; and, in the intermediate path which Spencer pursues, between popular empiricism and *a priori* speculations, the conception of an evolutionary process certainly assumes an original character. Spencer has been led into this course by his closely inductive genius. He is opposed to too abstract generalizations, and likes generalizations to imply carefully-observed facts; but, by a bold synthesis, he surpasses all that his predecessors have achieved by analysis only. This equilibrium of faculties makes Spencer worthy of being considered in more aspects than one. He marks in the history of psychological inquiry the latest stage that the inductive method has attained in England by the work of a powerful mind impressed with the refinements of modern science; and this is not less true, although some traits, and particularly a certain metaphysical touch in the works of this most distinguished philosopher, remind us of Schelling and Hegel. The tendency of the method of the English school, as it is applied by Spencer, seems to become ever more and more distinct from the general tendency of psychological studies on the Continent, and marks in him the climax of the course of thought exhibited, in successive phases, by James Mill, John Stuart Mill, and Alexander Bain. It is a movement of thought, implying the tendency to find the basis of mental science in the knowledge of concrete facts, and the progress of that tendency we can estimate by the successive advances made in psychological analysis by Hartley, James Mill, Bain, and Spencer. The inquiry into the facts of the world of consciousness, as we have indicated, had no definiteness in the vague mechanism of Hartley and James Mill; it was more logical in John Stuart Mill, more minute in Bain, and is to-day broader and more comprehensive in Spencer, who is the one so

far that has brought the theory of the reduction of psychological facts to the finest point. But with respect to the substance of method and details of analysis he has, in common with Mill and Bain—in fact, with all the school—that which constitutes the organism of English psychology and gives it a physiognomy of its own in contemporary history."

ELEMENTS OF DYNAMIC. AN INTRODUCTION TO THE STUDY OF MOTION AND REST IN SOLID AND FLUID BODIES. By W. K. CLIFFORD, F. R. S. Part I., Kinematic. New York: Macmillan & Co. Pp. 221. Price, $2.50.

THIS little book plunges into depths where only mathematicians can follow; but its opening sentences are so characteristic of the author's clearness of perception and statement, that, as they involve no formula, and are withal instructive, we quote them:

"Just as geometry teaches us about the *sizes* and *shapes* and *distances* of bodies, and about the relations which hold good between them, so dynamic teaches us about the changes which take place in those distances, sizes, and shapes (which changes are called *motions*), the relations which hold good between different motions, and the circumstances under which motions take place.

"Motions are generally very complicated. To fix the ideas, consider the case of a man sitting in one corner of a railway-carriage, who gets up and moves to the opposite corner. He has gone from one place to another; he has turned round; he has continually changed in shape, and many of his muscles have changed in size during the process.

"To avoid this complication we deal with the simplest motions first, and gradually go on to consider the more complex ones. In the first place, we postpone the consideration of changes in size and shape by treating only of those motions in which there are no such changes. A body which does not change its size or shape during the time considered is called a rigid body.

"The motion of rigid bodies is of two kinds; change of place, or *translation*, and change of direction or aspect, which is called *rotation*. In a motion of pure *translation*, every straight line in the body remains parallel to its original position; for, if it did not, it would turn round, and there would be a motion of *rotation* mixed up with the motion of translation. By a *straight line in the body* we do not mean merely a straight line indicated by the shape or marked upon the surface of the body; thus, if a box have a movement of translation, not only will its *edges* remain parallel to their original positions, but the same will be true of every straight line which we can conceive to be drawn, joining any two points of the box.

"When a body has a motion of translation, it is found that every point of it moves in the same; so that to describe the motion of the whole body it is sufficient to describe that of one point. When a body is so small that there is no need to take account of the differences in position and motion of its different parts, the body is called a *particle*. Thus the only motion of a particle that we take account of is the motion of translation of any point in it.

"A motion of translation mixed up with a motion of rotation is like that of a corkscrew entering into a cork, and is called a *twist*.

"Bodies which change their size or shape are called *elastic* bodies. Changes in size or shape are called *strains*.

"The science which teaches how to describe motion accurately and how to compound different motions together is called *kinematic*."

The volume is a college text-book, and the genius and position of its author are a sufficient guarantee of its originality and excellence. Prof. Clifford has broken down so sadly in health that he has been compelled to suspend work at University College, in London, and leave England for the more genial climate of Southern Europe. His work on the "Fundamental Ideas of Mathematics and Physics explained to the Non-Mathematical," with which he has been long occupied for the "International Scientific Series," is well advanced, and it is to be hoped that he will recover his health to complete it, and carry out the other important intellectual projects of which his teeming head is full.

PHYSICAL TECHNICS. By Dr. J. FRICK. Translated by J. D. EASTER, Ph. D. With 797 Illustrations. Philadelphia: Lippincott. Pp. 467. Price, $2.50.

TEACHERS of physical science and students who are without the aid of competent instructors and good laboratory apparatus will find this a very useful manual. The volume, in the first place, contains a great deal of valuable, practical instruction for making experiments in physics. The manipulation of apparatus, the construction of apparatus at the least possible cost, the points to be considered in the purchase of instruments, on these and many other like topics the author supplies a good deal of common-sense information, gathered in the course of his own experience as a teacher of science, and selected from technical manuals. Having aided the student in choosing his apparatus or constructing it, and given him some insight into the secrets of physical manipulation, the author, in the

second part of the book, gives directions for making experiments illustrative of the principal laws of physics, as the equilibrium of forces, motion, acoustics, light, magnetism, heat, etc. The work appears to be very well adapted to meet the wants of the reader for whom it is intended.

CURRENT DISCUSSION: A Collection from the Chief English Essays of Questions of the Time. Edited by EDWARD L. BURLINGAME. Vol. II., Questions of Belief. New York: G. P. Putnam's Sons. Pp. 360. Price, $1.50.

THE first volume of this new series of reprinted contemporary discussion was devoted to international politics, and very naturally gave special prominence to the treatment of the Oriental question which has latterly excited so much attention. It consisted of a judicious selection of the most important papers that have appeared in the English reviews by distinguished writers on the various aspects of Eastern politics. The second volume, devoted to what the editor terms, somewhat vaguely, "Questions of Belief," is occupied with radical speculations in theology, most of the space being taken up by the Symposiums from the *Nineteenth Century* that have appeared in THE POPULAR SCIENCE SUPPLEMENT. There is an article on "The Course of Modern Thought," by G. H. Lewes; one on "The Condition and Prospects of the Church of England," by Thomas Hughes; and the paper of W. H. Mallock entitled "Is Life worth living?" Nothing needs to be said in commendation of these able discussions, and they are brought out in a neat and attractive shape by the publishers.

FERNS OF KENTUCKY. By J. WILLIAMSON. Louisville: J. P. Morton & Co. Pp. 154. $2.

THE collector of ferns in Kentucky will find in this neat little volume a guide to the principal localities in which the different kinds occur, and a key for determining the different species which he meets in his rambles. The volume further contains hints on the cultivation of ferns, and on the proper method of drying and preserving them. Sixty full-page etchings and six woodcuts serve to illustrate the ferns of Kentucky.

BULLETIN OF THE UNITED STATES GEOLOGICAL AND GEOGRAPHICAL SURVEY OF THE TERRITORIES, F. V. HAYDEN, Geologist-in-Charge. Vol. IV., No. I. Washington: Government Printing-Office. Pp. 311.

THE memoirs contained in this number of the *Bulletin* are all on zoölogical subjects, viz.: "The Ornithology of the Lower Rio Grande of Texas;" "Fishes from the Cretaceous and Tertiary, west of the Mississippi;" three papers on "*Tineina*;" "*Noctuidæ*, chiefly from California;" "The North American Species of *Alpheus*;" "Mammals of Fort Sisseton, Dakota;" "American *Herodiones*;" "Butterflies from Southern Utah;" "Herpetology of Dakota and Montana;" "Consolidation of the Hoofs in the Virginian Deer;" "A Breed of Solid-Hoofed Pigs;" "Prof. Owen on the *Pythonomorpha*."

MANUAL OF THE APIARY. By A. J. COOK, Professor of Entomology in the Michigan State Agricultural College. Chicago: T. G. Newman & Son. Pp. 286. Price, cloth, $1.25; paper, $1.

A LARGE edition of this "Manual" having been sold within two years of its first publication, Prof. Cook was encouraged to revise the work and make it more complete in both its scientific and practical aspects. The result is a handsome volume, elegantly illustrated, and containing all the information needed by those who desire to keep bees. We have received, from the same author, a pamphlet on "The Hessian Fly," giving its natural history and habits, and describing the methods of protecting the wheat-plants against its ravages.

MANUAL OF THE VERTEBRATES OF THE NORTHERN UNITED STATES. By DAVID STARR JORDAN, Ph. D., M. D. Second edition, revised and enlarged. Chicago: Jansen, McClurg & Co. 1878. Price, $2.50.

IT speaks well for this book, and for the growing activity in natural history studies, that it has grown to become so useful an apparatus in its own line. It is barely four years since that novel *brochure* appeared of Jordan and Van Vleck, "A Popular Key to the Birds, Reptiles, Batrachians, and Fishes, of the Northern United States, east of the Mississippi River." Soon came as an outgrowth the "Manual of the Verte-

brates;" and now comes its second edition. To Elliott Coues must always be given the merit of leading grandly on this line by the "Key to American Birds." Prof. Jordan has, in this new book of over 400 pages, put the amateur student in the classification of the home vertebrates under a great debt of gratitude. The manual is a very efficient analyst of animal forms. It is truly *multum in parvo*, but perhaps a little too condensed.

TWENTY-FIVE-CENT DINNERS FOR FAMILIES OF SIX. By JULIET CORSON, Office of the New York Cooking-School, 35 East Seventeenth Street, Union Square. 72 pages. Price, 15 cents.

MISS CORSON has published various useful books on the subject of cookery, and, among others, a little *brochure* entitled "Fifteen-Cent Dinners for Working-Men's Families." This attracted a good deal of attention, and set many people to thinking about the possibilities of living cheaply and well, if they only knew *how* to do it. Having thus raised the question of economical diet in a practical way, Miss Corson was applied to by letters from numerous parties to show what could be done on a little more liberal scale of expense, and "Twenty-five-Cent Dinners" is the result. There is a large amount of valuable, well-digested information in this pamphlet. Miss Corson not only speaks from experience, both in cooking and teaching (as she is superintendent of the New York Cooking-School), but from a special study of culinary economics, or how to get good food in sufficient allowance at the lowest cost. Her results will excite some surprise in people of careless habits in these matters, and who would be astonished to be told that good cookery would give them better diet than they are in the habit of getting, at half the cost. Miss Corson begins with some serviceable hints on marketing, and the economical selection of articles of food, and then offers various valuable suggestions on the best methods of cooking to make them go the farthest. Several chapters follow of well-selected receipts for economical dishes, and the whole is fully indexed at the close. Besides her suggestive preface, addressed "To Economical Housewives," she offers at the outset the daily bills-of-fare for one week, with the price of each dish, of each meal, of the three daily meals, and the total meals of the week. The dishes are wholesome, attractive, and by no means stinted, and their very moderate cost conveys an instructive lesson to lax and thriftless housekeepers. Miss Corson's little work is opportune in these stringent times, and its wide circulation would be productive of much public benefit.

BULLETIN OF THE MINNESOTA ACADEMY OF NATURAL SCIENCES (1877). Minneapolis: Young & Winn print. Pp. 126. Price, 50 cents.

THIS number of the *Bulletin* contains, besides the annual address of the president, a report on the "Mycological Flora of Minnesota," another on "Ornithology," a paper on "Tornadoes and Cyclones," and the Curator's "Report." The additions to the Academy's Museum were larger in 1877 than in any previous year, besides being much more valuable.

PUBLICATIONS RECEIVED.

Short Studies of Great Lawyers. By J. Browne. Albany: *Law Journal* print. Pp. 382. $2.

The Nature of Things. By J. G. Macvicar, D. D. Edinburgh: *Blackwood*. Pp. 120.

How to take Care of our Eyes. By H. C. Angell, M. D. Boston: Roberts Brothers. Pp. 70. 50 cents.

Handbook of Modern Chemistry. By C. M. Tidy. Philadelphia: Lindsay & Blakiston. Pp. 795. $5.

Report of the Commissioner of Education (1876). Washington: Government Printing-Office. Pp. 1152.

The Native Flowers and Ferns of the United States. Parts 3, 4, 5. Illustrated by Chromo-lithographs. Boston: L. Prang & Co. 50 cents each.

New Encyclopædia of Chemistry. Parts 31 to 35 inclusive. Philadelphia: Lippincott. 50 cents each.

The Dance of Death. By W. Herman. New York: American News Company. Pp. 131.

In the Wilderness. By C. D. Warner. Boston: Houghton, Osgood & Co. Pp. 176.

Dosia. By H. Greville. Boston: Estes & Lauriat. Pp. 260. $1.50.

Instructions for observing the Total Solar Eclipse of July, 1878. Washington: Government Printing-Office. Pp. 30, with Plates.

Report of the Wisconsin Dairymen's Association (1878). Madison: Atwood print. Pp. 150.

Sound and the Telephone. By C. J. Blake, M. D. Pp. 14.

True and False Experts. By E. Gissom, M. D. From *American Journal of Insanity*. Pp. 36.

Report of the New York Meteorological Observatory (1877). New York: Lees print. Pp. 32.

Follies of the Positive Philosophers. By T.

L. Clingman. Raleigh, N. C.: Nichols print. Pp. 25.

Twenty-five Cent Dinners for Families of Six. By J. Corson. Pp. 72. 15 cents.

Separation and Subsequent Treatment of Precipitates. By F. A. Gooch. From "Proceedings of the American Academy." Pp. 8.

Vortrag über den Mexicanischen Calender-Stein. Von Prof. Ph. Valentine. New York: Marrer und Sohn. Pp. 33, with Plates.

Instinctive Operations of the Human System. By J. F. Hibberd, M. D. Cincinnati: *Lancet* print. Pp. 16.

Malaria and Struma. By L. P. Yandell, M. D. From *American Practitioner*. Pp. 15.

Honest Money. By T. M. Nichol. Chicago: The Honest Money League of the Northwest. Pp. 56.

Report of the Board of Schools, St. Louis (1876–77). St. Louis: Daly & Co. print. Pp. 280.

Notes from the Chemical Laboratory of the Johns Hopkins University. Nos. 9—12.

Duty of Literary Men. By Rev. T. A. Goodwin. New York: Burns & Co. Pp. 16.

Spelling Reformer. Vol. I., No. 5. Same publishers. Pp. 6.

The Currency. By J. Johnston. Chicago: Honest Money League of the Northwest. Pp. 38.

Physical Exercise and Consumption. By Dr. R. B. Davy. Cincinnati: From the *Lancet and Observer*. Pp. 16.

POPULAR MISCELLANY.

The Recent Solar Eclipse.—The telegraphic reports from the various stations for observing the solar eclipse of July 29th are of necessity meagre and confused. The atmospheric conditions were eminently favorable along the line of totality, indeed in the whole region west of the Mississippi, while throughout the East clouds generally concealed the phenomenon from view. Dr. Henry Draper, stationed at Rawlins, Wyoming Territory, took four photographs of the corona, two of them with his large spectroscope. These latter are declared to be "very sharp and full of detail." This is a very fortunate circumstance, for it will enable scientific men to ascertain the precise truth touching a very important difference between the observations of Dr. Draper and those of the other astronomers. Dr. Draper reports that he finds the corona spectrum marked with the usual Fraunhofer's lines of the sun's spectrum. These lines were not seen by the other observers, whether at the same station or at the many other stations in the track of the total eclipse. Mr. Lockyer, in a dispatch, says that "Newcomb's party and Barker made careful search for dark lines in the corona, but none were observed. Young," he adds, "telegraphed that there were no lines observed in the ultra-violet at Denver." Again, most of the spectroscopic observers report the presence of bright lines in the coronal spectrum, Prof. Young seeing several bright bands, and in particular the Kirchhoff line 1447. This observation, too, is negatived by that of Dr. Draper, whose photographs of the corona exhibit none of these bright lines. The world of science will await with profound interest the minute examination of all these coronal photographs; the result will decide whether, in accordance with the almost unanimous opinion of physical astronomers, the corona is a self-luminous liquid or solid body, or only reflected sunlight.

Prof. Langley, stationed at Pike's Peak, Colorado, reports that he "saw the corona elongated;" that it "resembled the zodiacal light." Further, that he "followed it a distance of *twelve diameters* of the sun on one side and three on the other." This observation, if confirmed (and we may observe that none of the other astronomers appear to have confirmed it), would go to prove an extension of the corona into space about five times greater than the highest estimate hitherto made. Search was made during the eclipse for an intramercurial planet. Herein only one of the observers, Prof. Watson, claims to have been successful: he reports having discovered an intramercurial planet, of magnitude four and a-half, in right ascension eight hours twenty-six minutes; declination north 18°. The solar protuberances were much less prominent than in most recent eclipses.

Prof. Colbert, of Chicago, stationed at Denver, Colorado, reports that his observations tend to show that the moon's path in the heavens lay a little farther to the southward than is indicated by the lunar tables, or else that the estimate of the moon's diameter is too large. Possibly both suppositions are correct. Of Edison's "tasimeter," Mr. Lockyer writes from Rawlins:

"The tasimeter, the new instrument on which Edison has been working unceasingly here, has proved its delicacy. During the eclipse he attached it to Thomson's galvanometer, which was set to zero. When the telescope carrying the tasimeter was pointed several degrees from the sun, the point of light rapidly

left the scale as the corona was brought upon the fine slit by which the tasimeter itself was protected."

Progress of the Electric Light.—Progress is being steadily made with the electric light, both in the sense of improving the apparatus needed for utilizing it and in finding for it practical application. In Paris the railway-station Gare St.-Lazare is now very effectively lighted with the aid of the instrument known as Lontin's distributing machine. The contrast between the pure, clear white electric light and the dull-yellow gaslights in the surrounding streets is enough to convince the most skeptical of the superiority of electricity over gas as an illuminating agent. In the Lontin machine ordinary prepared carbon-wicks are employed, which are regulated by a Lontin burner: the light is remarkably steady, and the wicks burn in the open air without globes or shades of any kind. A strong objection to this machine, unfitting it for use in private houses, is the hissing noise it makes when in operation. The electric candle invented by Jobloshkoff is used for illuminating the Place de l'Opéra in the same city. Across the open area of the Place, and extending toward the new Avenue de l'Opéra, there is a double row of large lamp-posts down each side, each surmounted by a large cylindrical lamp of clouded glass, and containing twelve electric candles. The whole space is lighted as bright almost as day. As soon as a candle burns down, another is moved by mechanism into its place without much appreciable disturbance of the general effect. There is no flickering. The great drawback to the Jabloshkoff candle is its costliness, the illumination being as expensive as when gas is used.

Bathing as a Cause of Ear-Disease.—Inflammation of the middle ear, often resulting in chronic deafness, is a not infrequent consequence of bathing. The damage, according to Dr. Sexton, in the *Medical Record*, consists in the admission of water to the ear, either through the external auditory canal or the Eustachian tube. When water finds admittance to the former, if cold or salt, inflammation of the meatus alone may result; or, if violently injected, as in surf-bathing, or long retained in the canal from diving, the disease may affect the drum-head and middle ear. Whenever water is forced from the mouth and nostrils into the middle ear through the Eustachian tube, inflammation of the middle ear is almost sure to occur, even though the water be warm. According to the author, several thousand severe cases of aural disease result annually from bathing in New York City alone. The bather, when in the surf, should take the water on his chest or back, with mouth and nostrils closed, and never presenting the ear to the in-coming wave. A firm pledget of cotton-wool in the ears is some protection.

The Carpet-Beetle.—Notices have appeared from time to time during the last four or five years of a new carpet-beetle said to be far more destructive than the familiar carpet-moth. This insect has been identified by Dr. J. L. Le Conte as *Anthrenus scrophulariæ*, a European species. A good account of it is given in the *American Naturalist* by Mr. J. A. Lintner, who has studied this insect attentively since its first appearance on our shores. The larva, he says, measures at maturity about three-sixteenths of an inch in length, and it is in this stage of its existence that *Anthrenus* preys upon carpets. A number of hairs radiate from its last segment in nearly a semicircle, forming a tail-like appendage almost as long as the body. The front part of the body, which has no distinct head, is thickly set with short brown hairs and a few longer ones. Similar short hairs clothe the body. The body has the appearance of being banded in two shades of brown, the darker one being the central portion of each ring, and the lighter the connecting portion of the rings. Having attained its full larval growth, it prepares for its pupal change without forming a cocoon, but merely seeking some convenient retreat. Here it remains motionless until it has completed its pupation, when the skin is rent along the back and through the fissure the pupa is seen. A few weeks later the pupal skin is split down the middle of its dorsal aspect, and the brightly-colored wing-covers of the beetle are disclosed. Soon after their emergence from the pupal case during the fall, winter, and spring, the beetles pair and the

females lay their eggs for another brood of larvæ. The *Anthrenus* once introduced into a house quickly infests it in every part. Thus, in a house at Cold Spring, New York, which had remained shut up for twelve months, they "took complete possession from the cellar to the attic, in every nook and crevice of the floors, under matting and carpets, behind pictures, eating everything in their way." No effectual means of combating this insect pest has yet been discovered; they are said to "grow fat" on camphor, pepper, tobacco, turpentine, carbolic acid, and the other ordinary applications.

The Earthquake-Scare in North Carolina.—Bald Mountain, in Western North Carolina, forming part of the Blue Ridge of the Alleghanies, has for two or three years been receiving a good deal of attention in the newspapers. Rumbling noises have now and then been heard in the mountain, and these were by the people of the surrounding country taken to be conclusive evidences of volcanic action. As is usual in such cases, these actual phenomena were magnified enormously by the popular imagination, and to them were added others which had no objective existence. Prof. Clarke, of the University of Cincinnati, having devoted the early days of his summer vacation this year to investigating the causes of these rumblings, declares, in a letter to the *New York Tribune*, that "Bald Mountain is no more an earthquake centre than is Central Park," and that "it is merely a locality in which some large rock-slides of an exceedingly gradual character are going on." Nevertheless, the mountain is an object well worthy of study. It forms one side of a pass through the Blue Ridge, Chimney Rock forming the other. While the latter mountain is made up of smooth sheets of what appears to be gneiss, Bald Mountain is all over cracked and fissured, the fissures in some places forming large caves. The recent disturbances have chiefly affected a low spur of the mountain, rising about one thousand feet above the valley. From below the appearance is as if the whole side of the spur was sliding down.

Prof. Clarke first climbed up the side of this spur to a cave which had been discovered a very short time previously. Here he found himself below a precipitous mass of rock two or three hundred feet high, at the foot of which immense numbers of fallen bowlders had formed crevices and caves innumerable. But the new cave was the largest of all. The floor of the cave was everywhere covered with fallen rocks. The newspaper accounts tell of powerful "currents of ice-cold air" issuing from the caverns; but Prof. Clarke found no strong currents, and a difference of only four degrees of temperature between the inside and the outside air. The "smoke of the Bald Mountain volcano" is not smoke at all, but fine dust formed by the grinding and clashing of the rocks. Prof. Clarke next visited "the Crack," a crevice very probably of quite recent origin. This is merely a rent in the rock about one hundred feet in length, seventy-five in depth, and nowhere over ten in width. The explanation given of these cracks and the noises is found in the geological constitution of the mountain, which is built up of sheets of an easily decomposable gneiss, inclined at a slight angle and sliding downward. These sheets of gneiss are full of cracks running at approximately right angles to the pseudo-stratification. The caves are merely spaces which have been left when an upper sheet of rock has slidden off and become inclined against a lower. Nowhere is any sign of volcanic action to be seen. As for earthquakes, the surrounding country is as free from them as any other in the whole country. Prof. Clarke accounts as follows for the rumbling noises: The rocks, as we have seen, are cracked across their stratification. When a large sheet of gneiss is gradually sliding down, there comes eventually upon some part of it a strain sufficient to produce a fracture. This breaking is, of course, attended by a noise, to which the immense caves and crevices serve as resounding chambers.

Material Resources of European Russia.—Russia in Europe, considered with regard to its economic products, may be divided into five distinct zones or regions, viz.: Starting from the north, the tundras, the forest and agricultural regions (forming three

zones), and the steppe. The peculiarities of each of these are described by a writer in the *Geographical Magazine*, who derives his information from authentic sources. Of the tundras, those bare, damp, arctic wastes, mostly situated between the arctic circle and the polar ocean, he says that in winter they are frozen, and that in summer they thaw to the depth of a foot or so. The tundra area is about 144,820 square miles, and almost the sole vegetable productions are turf-moss and reindeer-moss. This region does not promise ever to be of any considerable economic value. The forest zone extends from the limit of trees southward to 60° north latitude, and embraces the greater part of Finland, the governments of Olonetz, Vologda, most of Archangel, and the northern districts of Novgorod, Vyatka, and Perm. Area, 815,790 square miles. Population, between thirteen and fourteen souls per square mile. The economic products are fur, timber, tar, and potash. The four northern governments of Archangel, Vologda, Olonetz, and Uleaborg, cannot expect ever to attain a much higher degree of cultivation than at present. The inhabitants prefer the chase to agriculture, and devote only three months in the year to the latter. The agricultural zone extends from the sixtieth parallel to the steppe. Of this zone, the northern and central portions are a diluvial deposit, forming a thin, sandy soil that requires plentiful manuring; but the southern zone, the "black-earth" region, yields rich harvests without manuring or labor. Thus this zone may be divided into two belts, northern and southern. The northern belt includes fifteen entire governments and parts of others, with a total area of 371,900 square miles; average population fifty-four to the square mile. The region yields too little wheat for the support of its inhabitants, i. e., of the minimum allowance, 2.3 *chetverts* per head, only 1.7 *chetvert* is produced at home. The industrial wealth of Russia is mostly confined to this northern agricultural zone, the centre of manufacturing industry being the government of Moscow. The forests are gradually being diminished, through supplying fuel to carry on these industries, and there is the same improvident waste of timber which is to be seen in our backwoods. The output of coal in the Moscow district rose from 1,500,000 *puds* in 1860 to 9,000,000 *puds* in 1872; in the same year the Polish yield was 17,500,000 *puds*. The coal-deposits on both sides of the Ural, though rich and easily worked, are only used for the neighboring iron and copper works. The southern agricultural zone is so destitute of timber that the only fuel obtainable there, besides the droppings of cattle, is dry, half-wooded grain-stalks. The total area of the "black earth" is estimated at 250,760 square miles, extending over twenty-two governments, eight of which belong to the steppe region. In addition to these, six of the West Russia governments and Poland are noted for their fertility. The wheat produced in the black-earth country amounts to more than two-thirds of Russia's total yield, while potatoes are chiefly grown in the Polish and Baltic provinces. The population of the black-earth region forms 53 per cent. of the entire population of the country, and its crops 68 per cent. of the total yield. The manufacture of sugar from the beet is carried on extensively in the Kiev government. The crying want of this region is good roads. The chief vegetation found on the steppe is grasses, spiniferous and leafless plants, bulbous plants, etc. Forest-growth and cultivation are found only near the rivers; fuel is very scarce. The population of the steppe zone is very sparse, and the chief dependence of the inhabitants is on their cattle. In the south and southeast portions of the empire horses are bred in great numbers. The steppe zone is also rich in oxen and sheep. The grape is cultivated here to a considerable extent. Southern Russia is furthermore the chief source of salt-supply to the other governments of the empire.

Meteorological Notes.—Prof. Loomis's ninth paper on meteorology in the *American Journal of Science and Arts* for July is based on the observations of the United States Signal Service made between September, 1872, and October, 1874.

In tracing the rise and phenomena of the great storms which traverse the northern United States and British America, observations made at Portland, Oregon, were stud-

ied. During the period named, comprising twenty-six months, there were sixty-three instances of low barometer, corresponding to eighteen different storms.

Each of these instances of low pressure appears to have moved eastward, and can be traced to the Atlantic coast. All occurred in the six colder months of the year, and were most numerous in January. Their origin appears to have been northwestward of Portland, and probably over the Pacific Ocean.

Simultaneously with low barometer at Portland, there occurred high barometer eastward from that city, at an average distance of about fifteen hundred miles. The areas of low barometer advancing eastward crossed the continent in an average period of five days. The path traversed, however, was not a direct one. The low-pressure areas were developed as far north as latitude 50°; but in the middle of the continent the centres of low pressure were in latitude 40°, whence the direction was north of east, reaching the coast in latitude 45°.

From observations, which include those made in a previous paper, it appears that areas of low pressure are not only preceded, but are followed, by areas of high barometer. These conditions, each succeeding the other, traverse the continent with wonderful uniformity. Mountain-ranges from 6,000 to 10,000 feet high do not arrest, and but slightly modify, the eastward movement of these great atmospheric waves.

The high barometer following the areas of low pressure in their progress is usually attended by winds of great violence, from the north and northwest, attaining in some cases a velocity of from thirty to fifty-seven miles an hour. Extreme cold occurred too in many instances, the mercury falling in one case to —36° Fahr.

A fact of great interest presented by Prof. Loomis in a former paper is more fully illustrated in the present one; it is this, that while the air continually flows inward and spirally upward in a storm-area, or area of low barometer, it as continually flows outward at great elevations to areas of high barometer, where it descends to the earth's surface. Here it resumes its motion inward toward the storm-centre, gathering vapor in its progress, to be condensed into rain. It is seen from this that a constant vertical circulation occurs. The tables and charts presented by Prof. Loomis, showing these facts, are elaborate and conclusive. The direction of the movement of the upper air is determined by that of the clouds which float in it.

"The clouds," says Prof. Loomis, "were in all cases seen to be moving away from the low centre outward, toward an area of high pressure, where the air descends to the earth; here it again moves inward, and finally upward, in the gyrations of the storm."

Death to the English Sparrow. — The right of the European house-sparrow to settle in the United States is hotly contested in the *American Naturalist*, by Dr. Elliott Coues, who regards that bird as an unmitigated nuisance. The author makes no secret of his aversion for the sparrow and his contempt for the sparrow's friends. The former is a "wretched interloper" that "does not do any appreciable good; does a very obvious amount of damage; and has no place in the natural economy of this country." The sparrow's friends are divided into five categories, viz.: 1. The silly ones (though Dr. Coues by a circumlocution avoids the use of this plain language, it is clear to see that he *means* it). This class is composed chiefly of "children, women, and old fogies." 2. Those who were instrumental in getting the birds here. 3. Quasi-ornithologists. 4. The *clacqueurs* of the quasis. 5. A very few intelligent and scientific persons. Having thus cleared the ground, Dr. Coues presents the specific articles of his indictment of the sparrow. In substance they are: 1. That the sparrows neglect entirely or perform very insufficiently the business they were imported to do, *videlicet* destroying worms and insects. 2. That they do "attack, harass, fight against, dispossess, drive away, and sometimes actually kill, various of our native birds which are much more insectivorous by nature than themselves." 3. That they commit great depredations in the kitchen-garden, orchard, and grain-field. 4. In this specification the author delicately alludes to certain evidences of a lack of moral restraint

in the sparrow, offensive to many persons. *Item*, nervous invalids are fretted and annoyed into positive illness by the unceasing noisiness of these birds. 5. "They (the sparrows) have at present practically no natural enemies, nor any check whatever upon limitless increase," though, even with the most unobjectionable species of birds, a check would be desirable. And now what course must we adopt in order to abate this sparrow nuisance?—for abate it we must, or else the sparrows will eat us all out of house and home. Dr. Coues's recommendations on this head are: 1. *Let the birds shift for themselves.* Take down the boxes and all special contrivances for sheltering and petting the sparrows; stop feeding them; stop supplying them with building-material. 2. *Abolish the legal penalties for killing them.* "Let boys kill them if they wish. Let them be trapped and used as pigeons or glass balls in shooting-matches among sportsmen." This last recommendation shows very plainly that Dr. Coues has lost all patience with the sparrow. For ourselves, we hope the evil will be checked by some different means.

Agencies of Nitrification.—The researches of Schloesing and Müntz in nitrification have resulted in the very important discovery of a *nitrifying* organism analogous to the ferment organism of yeast. The evidence of the existence of a nitrifying organism is found in the fact that the process of nitrification, however actively it may be going on, is immediately stopped when chloroform-vapor is introduced, the effect being precisely the same as that seen when chloroform-vapor comes in contact with yeast. Again, these authors find that when nitrification has thus been stopped for several weeks, the addition of a small quantity of a nitrifying body will start the process again. They also find that the temperature of boiling water is sufficient to destroy all power of nitrification, and that soil which has once been heated to that point produces, in air free from germs, carbonic acid and ammonia, but no nitrates. If, however, this soil is moistened with water containing a little untreated soil, the production of nitric acid again commences. This new theory, as we learn from *Nature*, has been tested in England with results fully confirmatory of the views set forth by Schloesing and Müntz. Hence the evidence is very strong that the nitrates in soil owe their origin to oxidation brought about by living organisms.

How Ants distinguish Each Other.—Ants are eminently pugnacious, and opposing hosts belonging to the same species may any day in summer be seen waging internecine wars on one another. But how are they able to distinguish friend from foe in their tumultuous strife? Mr. McCook, member of the Academy of Natural Science of Philadelphia, has made sundry experiments which appear to show that *difference of odor* constitutes the means of discrimination. Of course, it is not possible to demonstrate this hypothesis directly by showing the existence, either of distinct odors, or of different intensity of odor, in opposing hosts. But, if we introduce into the scene of conflict some strong foreign odor which shall obliterate the odors peculiar to the two groups of combatants, we may deprive them of the power of telling friend from foe, and make them live together in harmony as one community. Such was the idea which occurred to Mr. McCook. He collected a number of combatants, and placed them, friend and foeman, together in a glass jar upon some soil. The battle was continued, and when it was again at its height a pellet of paper saturated with cologne-water was introduced into the jar. The effect was instantaneous. The ants showed no signs of pain, displeasure, or intoxication; indeed, some ran freely over the paper. But in a very few seconds the combatants had unclasped mandibles, released their hold of enemies' legs, antennæ, and bodies, and after a momentary confusion began to burrow galleries in the earth with the utmost harmony. The *quondam* foes dwelt together for several days in unity and fraternity, amicably feeding, burrowing, and building. Another experiment was as follows: A large number of warring ants were placed in a box partly filled with soil, and communicating by a glass tube with a smaller box. The larger box was about ten inches long and eight inches in depth and width; both boxes had sliding glass covers. Cologne was introduced as before into that end of the box in which the comba-

tants were principally engaged. In less than two minutes every sign of hostility had ceased except in the case of one small group and two single combatants in the opposite end; but a small pellet of perfumed paper, dropped in their neighborhood, put an end to the battle here. Previous to this, occasional stragglers had passed along the connecting glass tube into the smaller box. Most of them seemed to be of one faction, only one of the opposition having entered, upon whom six or eight ants were expending their wrath. This was the only remaining centre of strife, when Mr. McCook replaced ants and earth upon their native territory. The battle was continuing there, between greatly-diminished numbers of course, after the removal of the large battalions into the box, but the application of a feather dipped in cologne to the neighborhood of the warriors caused the instant cessation of controversy. The next day there were no ants found upon the surface, but digging two inches under ground, close by the fence, he observed a few. The battle was evidently over. There had been in the mean time a great change of temperature, from 96° to 47° Fahr., and this may have had some effect in sending the ants underground.

How the Lake-Dwellers lived.—A recently-published work on "The Lake-Dwellings of Switzerland" throws much needed light on the mode of life followed by the inhabitants of those curious constructions. That they must have been expert fishermen is shown by the large number of fish-skeletons, especially the skulls of very large pike, found buried among the piles. So, too, the bones, which lie about in the lake-dwellings in astonishing numbers, of stags, roes, wild-boars, beavers, squirrels, etc., are an evidence of the abundance of game, and of the ability of the settlers to capture even the higher description of wild animals. But the lake-dwellers did not depend on the chance products of hunting and fishing. They had already domesticated many of the animals, which to-day are the companions of man—as cows, sheep, goats, pigs. A great variety of seeds and plants were also cultivated by them for their own use and that of their domesticated animals. They cultivated flax of excellent quality; and their textile and other manufactures show considerable proficiency and skill. Tools and utensils of flint, of bronze, and of iron, have been found in the sites of these lake-dwellings, and the question arises whether the inhabitants were one people through the three successive ages of Stone, Bronze, and Iron, or whether each age was heralded by a new invasion. The evidence goes to prove the former hypothesis, of one race successively advancing from one stage of civilization to another.

Rapid Decay of Timber.—Till recently chestnut-timber has been always employed for beams in constructing houses in Rome, but, in most of the houses built since the occupation of the city by the Italian Government, pine joists have been used. After a few years the roofs and floors in which the pine had been employed were found to be falling, the joists having rotted at the point of junction with the walls, while the intermediate portions remained sound. The cause of this decay was discovered by accident on taking down the scaffold which had been erected for the use of the workmen engaged in building the hall of the Ministry of Finance. A correspondent of Prof. Tyndall's, writing from Rome, states that around one of the scaffold-poles, which was imbedded some four feet in the ground, had accumulated a heap about six feet high of pozzuolana mortar—that is, mortar made of lime and the peculiar argillaceous sand, of volcanic origin, known as pozzuolana. The underground portion and that above the mortar-heap were perfectly sound; that covered by the mortar was utterly rotten. Hence it was clear that the mortar was to blame. In what respect, then, does Roman mortar differ from that used in Venice, for instance, where pine-timber has stood in mortar for centuries without impairment? The sole difference was in the use of pozzuolana, which therefore seems to have some special chemical affinity for pine, while, as regards chestnut, it is neutral. It is stated that, in consequence of this peculiar action of the Roman mortar on the pine-timbers of the numerous buildings erected on the Esquiline Hill since 1870, many of the roofs and floors have had to be renewed.

NOTES.

In consequence of the growing interest in Industrial drawing and of the few facilities in the State for instruction in this subject, the Faculty of Cornell University have consented to receive teachers as special students, and to afford them all the advantage which the university offers in the various departments of drawing. The departments now established are free-hand drawing, mechanical engineering, civil engineering, and architecture. Special students will enter the same classes as the general students, and on the same terms. No one but teachers will be received—no entrance examination will be required, and no diplomas will be given.

The remains of a mastodon were lately found near Elkhart, Indiana, which evidently belonged to a monster specimen, one of the largest yet discovered. The section of a tusk which was unearthed gave evidence of having been about ten feet long. A monster tooth, six inches over the top, exceedingly well preserved, was dug up, and a shoulder-bone, which shows the animal to have been at least twelve feet high. The bones are to be presented to the city Museum Association lately formed at Elkhart. Several large specimens of the remains of mastodons have been found in Elkhart and adjoining counties within the past four or five years.

The German Association of Naturalists and Physicians will assemble this year at Cassel on September 18th, the sessions continuing for one week. Among the addresses promised are the following: "Relations of Darwinism to Social Democracy," by Oscar Schmidt; "Symbiosis, Parasitism," etc., by Prof. De Bary; "The Education of the Physician," by Prof. Fick; "The Color-Sense and Color-Blindness," by Dr. J. Stilling.

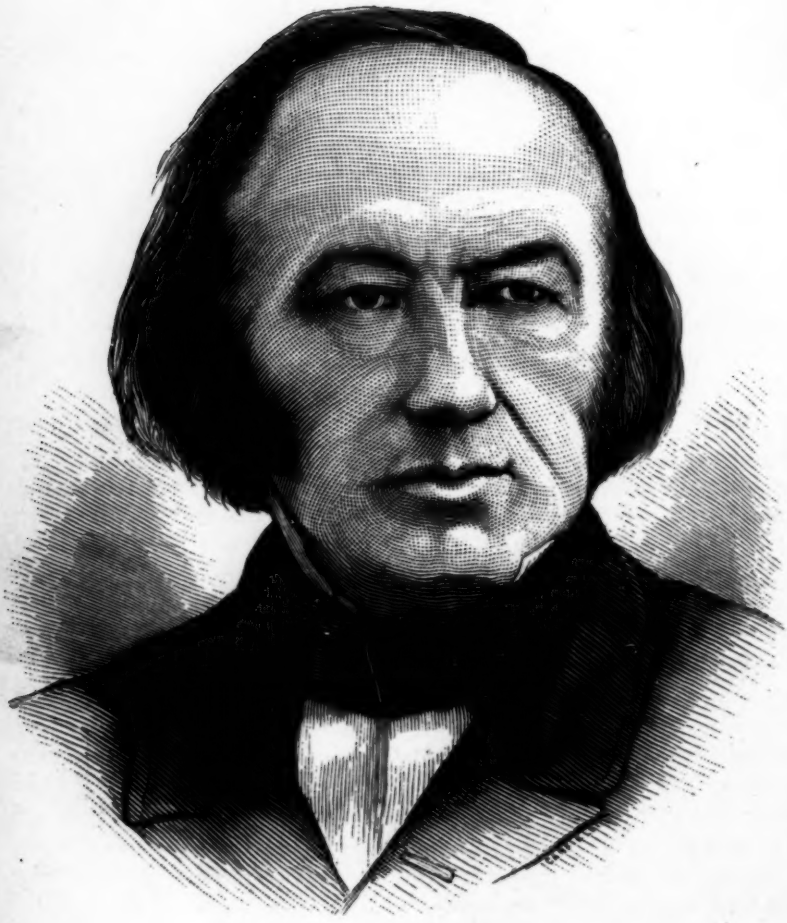
We regret to announce the death, at Philadelphia, of William M. Gabb, paleontologist, at the early age of thirty-nine years. His life-work commenced in 1862, when he was appointed as paleontologist on the staff of Prof. Whitney in the Geological Survey of California. In 1868 he visited Santo Domingo and made a survey of that island. He went on a similar mission to Costa Rica in 1873. "His various contributions to science," says the *American Journal of Science*, "are a great honor to the country, and eminently so to the State of California, for which a large share of his work was done."

Dr. Carl Rokitansky, for thirty years Professor of Pathological Anatomy in the University of Vienna, died in that city on July 23d, aged seventy-four years. His greatest work, a "Manual of Pathological Anatomy," was translated into English, and published in London by the Sydenham Society.

The death of Admiral Sir George Back is announced, aged eighty-one years. Back entered the naval service of Great Britain in 1808, and the following year was taken prisoner by the French, and held in captivity till 1814. In 1819 he did noble service with Franklin in exploring the extreme northernmost coast of America. His perseverance and his fertility of resource on that expedition were above all praise. In 1825 he again visited the arctic regions under the same commander. On both of these expeditions the explorers were rescued from death in the inhospitable north by the heroic exertions of Back. He commanded polar expeditions in 1833–'35 and 1836–'37.

The Commissioner of Agriculture has recently appointed Prof. J. H. Comstock, of Cornell University, and Prof. A. R. Grote, of Buffalo, New York, director of the Buffalo Society of Natural Sciences, as special examiners, under the direction of Prof. C. V. Riley, entomologist of the department, in an investigation now being initiated of the insects injurious to the cotton-plant. Several local observers in various parts of the South have also been appointed, and it is the intention of Prof. Riley to make a complete report on all insects affecting the Southern staple and the best means of counteracting their injuries, that shall be to the people of the South what the report of the entomological commission on the Rocky Mountain locust is to the people of the West. The department is especially fortunate in securing the services of Prof. Grote for this undertaking, as he has already given the subject much attention, and has carefully worked out the life-history of the cotton-worm, one of the worst enemies of the cotton-plant. The results of these investigations are contained in a paper read at the Hartford meeting of the American Association for the Advancement of Science, and published in the "Proceedings" of that year.

To ascertain the influence of light upon cement, Heinzel divided into three portions a lot of cement, and exposed one of these (A) to the air and full light, another (B) to the air and diffused light, and secluding the third (C) in darkness from the air. After six months it was found that A made a weak mortar by absorbing 38 per cent. of its weight in water, and it had become friable; B with 33⅓ per cent. of water made a mortar too adhesive to the trowel, and it yielded up some of its water; C with 33⅓ per cent. of water made an excellent mortar, easily stirred and flowing, and it parted with some of its water. After setting for twenty-eight days, the relative strengths were A 3, B. 37.9, C 44.6.



CLAUDE BERNARD.